AGRICULTURAL ENGINEERING

APRIL • 1954

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Power Characteristics of a Plunger-Type Forage Baler

•

What Farmers Want and Need in Tractors and Implements

•

Equipment for Measuring the Resistance of Potatoes to Bruising

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Design and Development of Thermal Destruction Apparatus

•

Results of Performance Studies of Bulk Cooling of Milk

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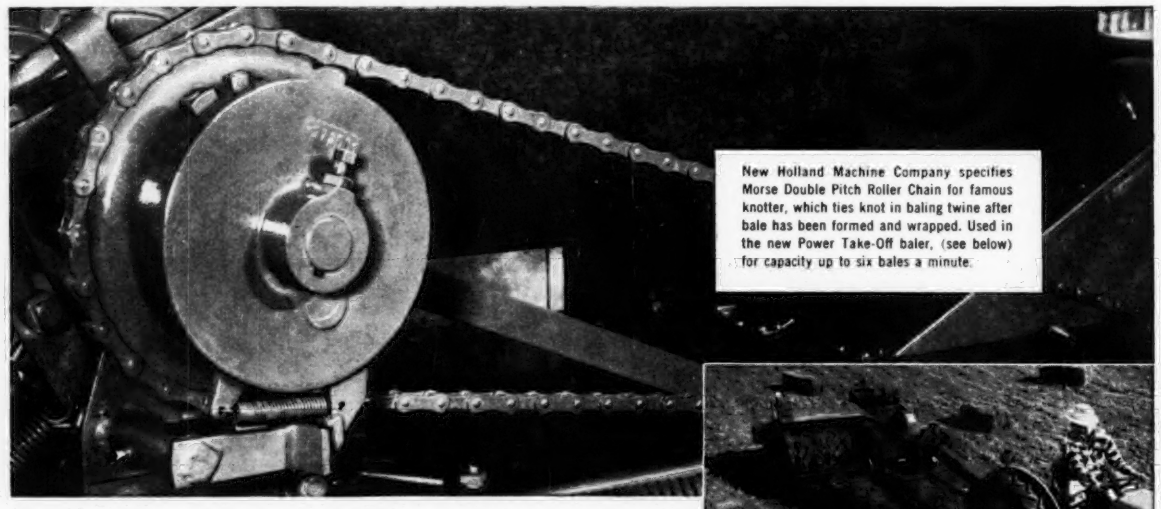

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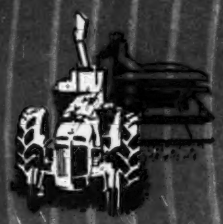

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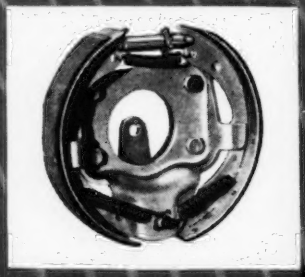

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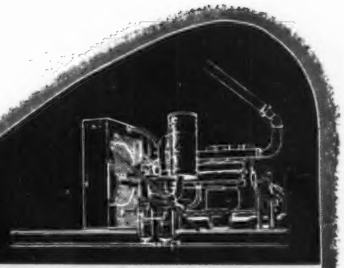

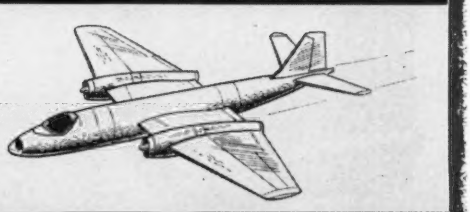

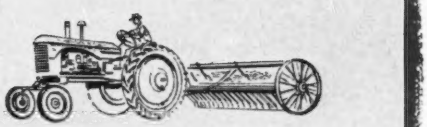

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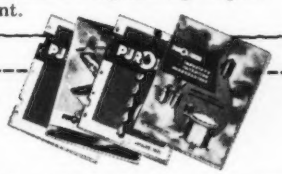

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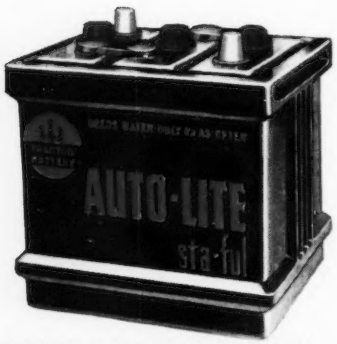

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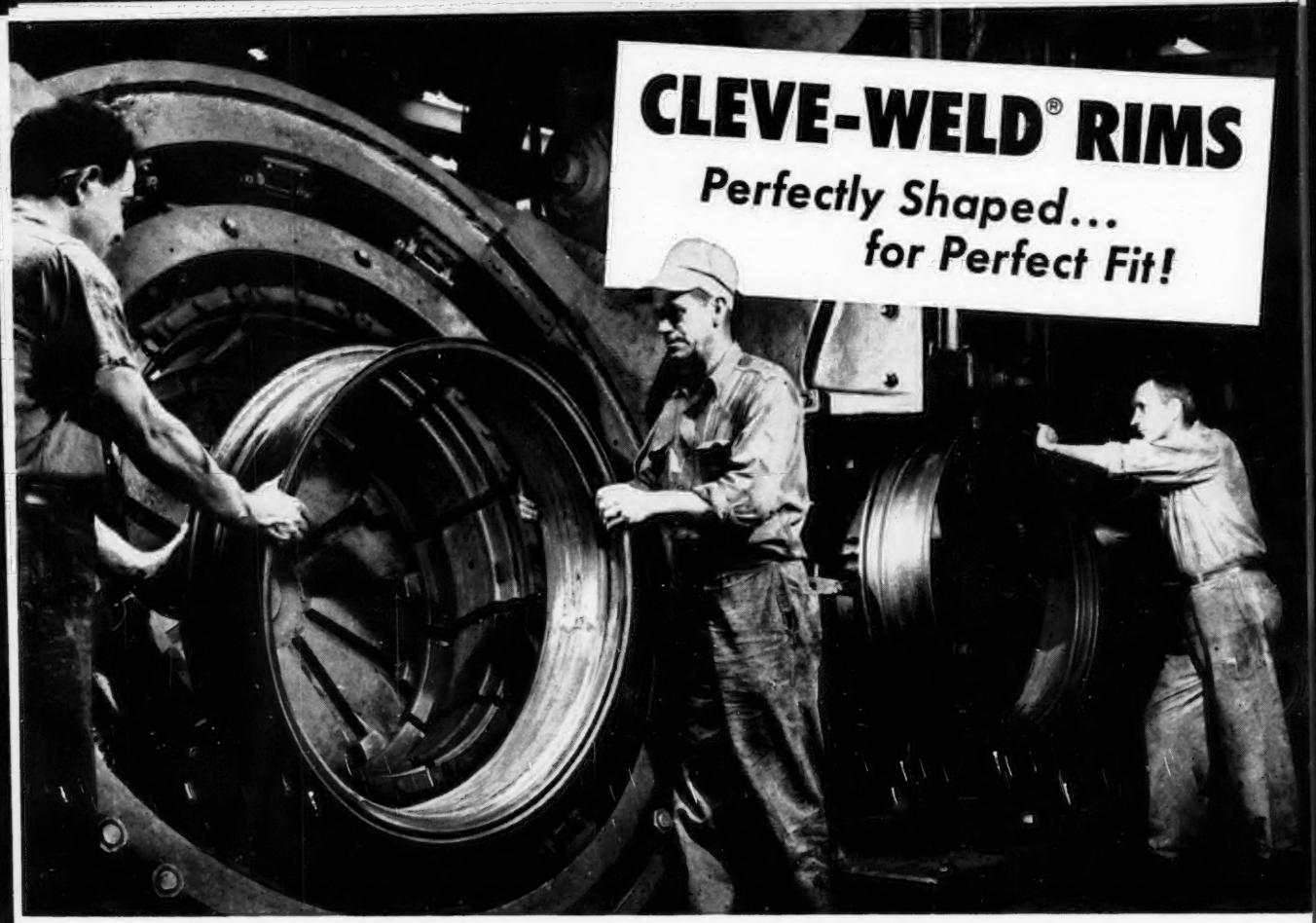

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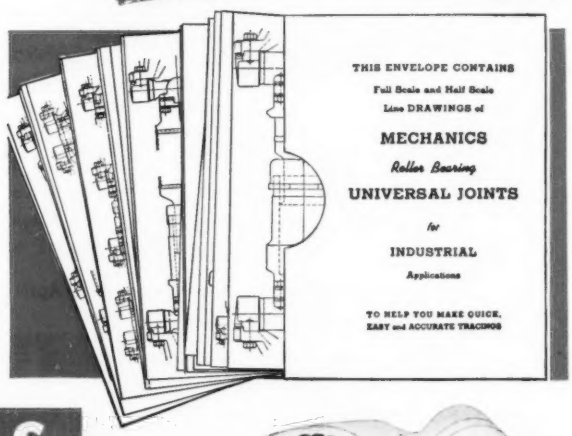

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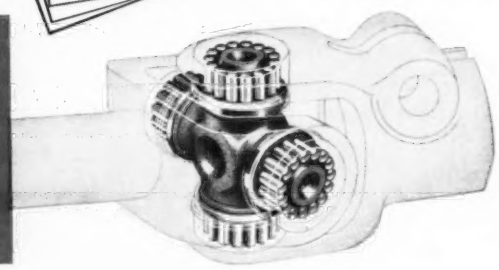

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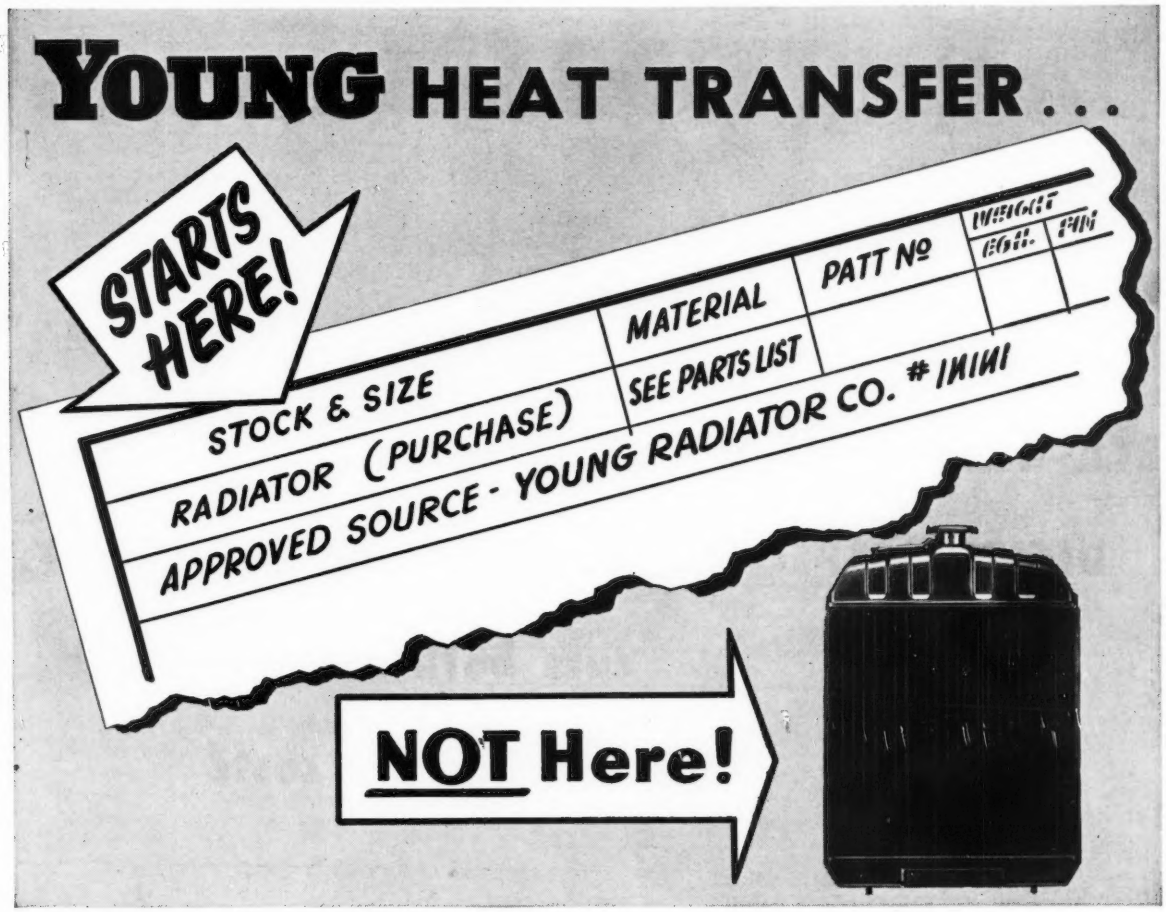

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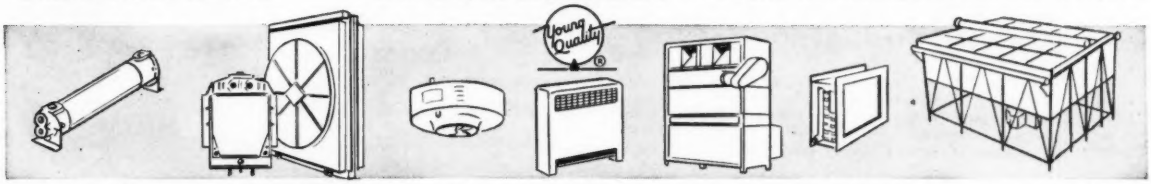

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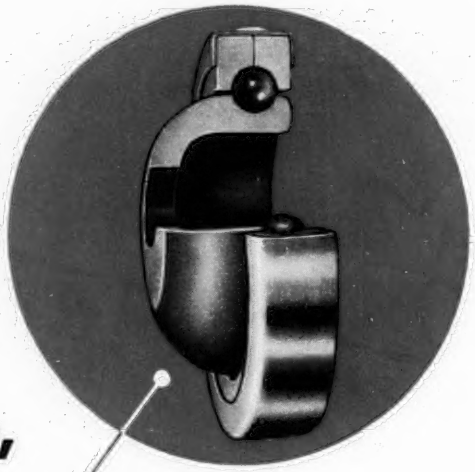

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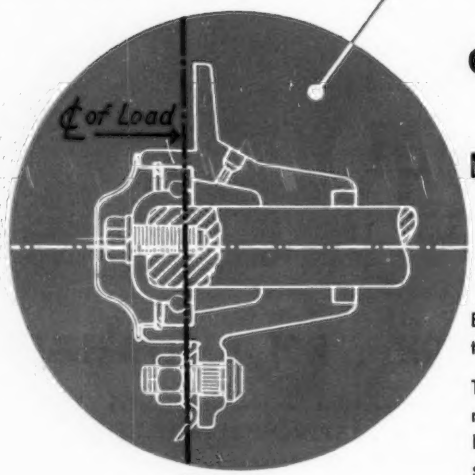

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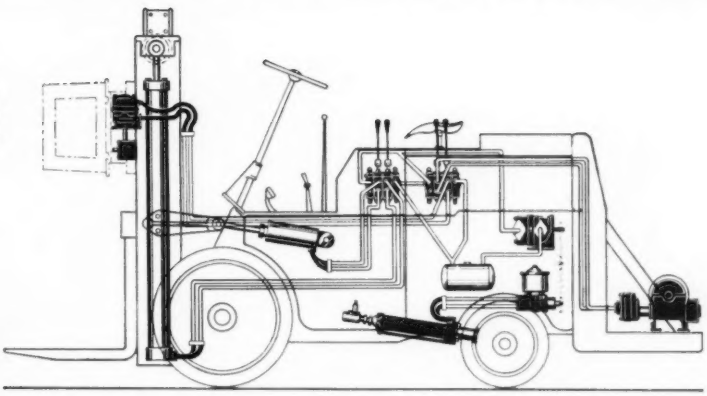

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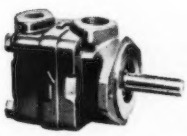

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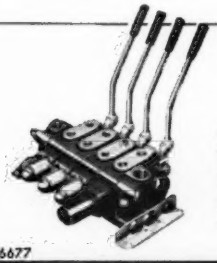

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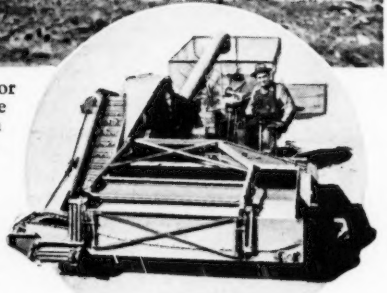
This novel machine picks up nuts from ground. Conveyer belt takes nuts to revolving cylindrical cage where they are cleaned. Nuts then go to trailer basket. Only one man is needed to operate the harvester.

Nut Harvester



Front view of nut harvester with inventor and builder, Mr. Leslie Ramacher, at the wheel. Mr. Ramacher built machine in his small shop near Stockton, California.

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The job of harvesting the crop of 400 acres of walnut trees on the Bishop Ranch, San Ramon, California, required a lot of manpower and costs were high, until Leslie Ramacher invented and built the nut harvester shown above. The use of the harvester completed the mechanization of the walnut grove, which started with tractor-operated tree shakers and air-powered pruners.

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"Marfak Lubricant sticks to bearings, doesn't jar off, wash off, melt down and drip out, or dry out and cake up. It seals out grit and dirt," says Texaco Man C. M. Shaw of Shelby, Mississippi *(right)*. Marfak protects bearings in equipment at Vieh Plantation, Deeson, Mississippi. Mr. E. P. Vieh, Jr., and daughter Barry are shown at left.

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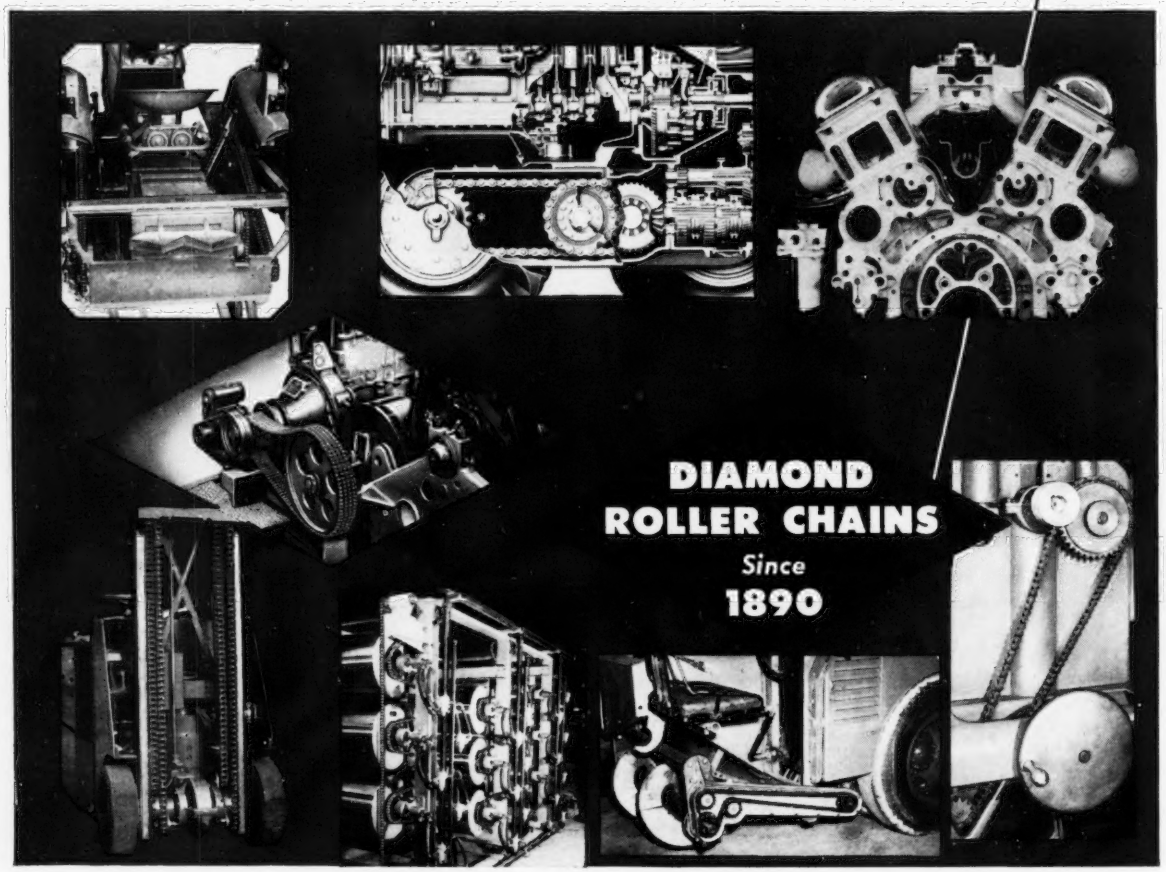

AGRICULTURAL ENGINEERING

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Power Characteristics of a Plunger-Type Forage Baler

D. E. Burrough and J. A. Graham
Assoc. Member ASAE Assoc. Member ASAE

ONE of the problems confronting the farm implement designer is the determination of the power distribution to the various components of a machine. The total power required to operate different machines has been determined under a few conditions, but this does not give the designer the information needed to design the component parts of the machine. Also, the power required depends upon the conditions under which the machine is operating.

A method by which field tests could be made on farm machinery to determine this distribution was developed by the agricultural engineering department of Purdue University. This method employed strain gages as a sensing unit for measuring the power input to various drives of the implement. Upon learning of this method of field testing The Oliver Corporation made an agreement with the University for conducting field tests on a new baler the company was then developing. The tests on the baler were to include power measurements to the auxiliary drives as well as the total input to the machine and the compression forces. The objectives of the testing program were to

- Determine the magnitude and characteristics of the total input to the baler
- Analyze the load characteristics of the compression force with reference to the factors affecting the magnitude of these forces
- Determine the total power requirements of the auxiliary drive.

Those results which apply to the over-all forage baler problems are reported in this paper.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Power and Machinery Division. Approved by the Director as Journal Paper No. 756 of the Purdue University Agricultural Experiment Station.

The authors—D. E. BURROUGH and J. A. GRAHAM—are, respectively, formerly professor of agricultural engineering, Purdue University, now special engineer, Bettendorf Works, J. I. Case Co., and formerly graduate student in agricultural engineering, Purdue University, now senior test engineer, Deere and Company.

Acknouledgment: The authors wish to express their thanks to The Oliver Corporation whose cooperation made possible the study reported in this paper.

REVIEW OF LITERATURE

Little information has been published on the power requirements of forage balers. Most of the measurements were made on stationary balers that did not have the present-day pickup and automatic knotters. The only power required by these balers was that needed to compress the material being baled.

One of the earliest references to the power requirements of balers was given in a report by Kinsman **(1)***, which included the total animal, mechanical, and electrical power being used on American farms at that time. He also gave the power required to operate the various agricultural tillage and harvesting machines. The baler requirement was given as 2 to 6 hp-hr per ton for hay and straw. The condition of the crop and the density of the bale could cause this wide range in the energy required to compress hay and straw.

McCuen **(2)** measured the power required to bale straw from three parts of a stack. The section of the stack from

*The bold-faced numbers in parentheses indicate the references appended to this paper.

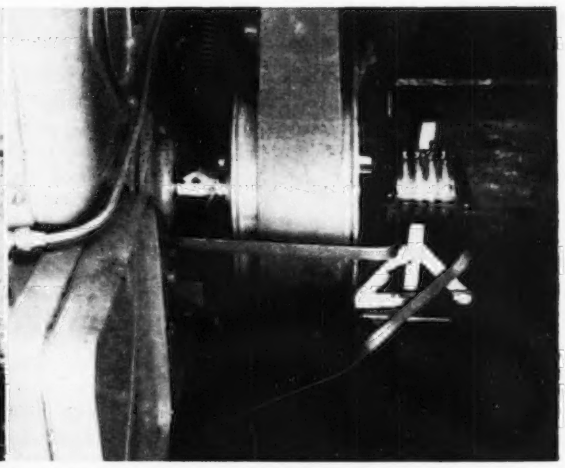

Fig. 1 *(Left)* Method of transporting the instruments used in the Purdue University field tests of the plunger-type forage baler • Fig. 2 *(Right)* View of field test equipment showing strain gages and pickup for measuring engine output

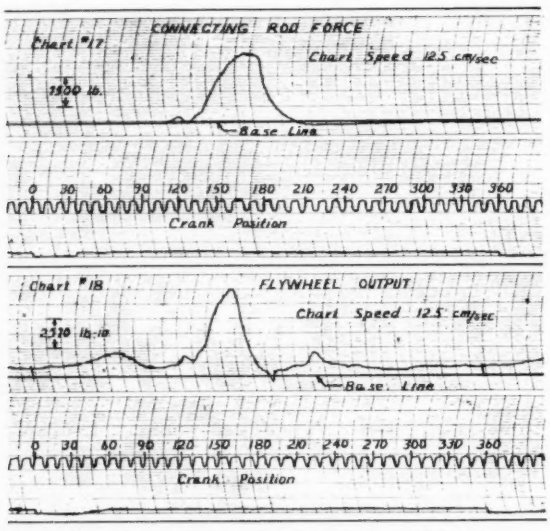

Fig. 3 Typical records of connecting-rod force and flywheel torque

which straw was being baled, the rate of baling and the power required are as follows:

Top section	1.564 tons per hour	6.23 hp
Middle section	1.83 tons per hour	6.64 hp
Bottom section	2.35 tons per hour	5.50 hp

The bale density was not given, but it was supposed to have been about the same for the bales from each section of the stack. It was also mentioned that the straw taken from the top of the stack was long and coarse while that from the bottom of the stack was mostly chaff. This is probably the reason for the lower power required when baling at a higher rate from the bottom of the stack.

In an investigation of the loads imposed on power take-off shafts by farm implements, Hansen (3) measured the total input required to operate two balers. The average and peak torque measured under normal operating conditions were given as follows:

		Max. torque, lb-in	Max. horsepower	Avg. torque, lb-in
Baler E	Alfalfa	6,550— 8,140	56-69	1545
Baler E	Straw	8,600—11,100	73-93	1580
Baler F	Alfalfa	8,600	73	—

Both balers tested were automatic-tying pickup balers. Power had to be supplied to these machines to operate the pickup feeder and automatic knotters as well as the power required to compress the material. Also, the capacity of automatic-tying balers is about one and a half times the capacity of stationary hand-tie balers. These two facts account for the differences in the power requirements given by the earlier investigators and Hansen.

Test Procedure

The power required by each drive of the baler was measured in alfalfa and wheat straw. The connecting rod forces, engine output and flywheel output were measured under several conditions of moisture and bale density in alfalfa. Three test runs were made at different baling rates for each condition. To obtain high rates of baling with low ground speeds, the amount of hay in the windrows was increased. Tests were conducted in alfalfa with a range in moisture content from 13 to 48 percent. The high-moisture hay was baled before it had cured, and the low-moisture hay had been left in the field for two days after it would normally have been put in the mow. The hay was baled at two or three different densities in each moisture content.

Each test run was for the period required to make one bale. A stop watch was used to obtain the elapsed time. As soon as a test bale was released from the bale chamber, it was weighed and measured. By dividing the weight of the bale by the time required to make the bale, the baling rate in pounds per minute was obtained. From the weight and dimensions of the bale, the bale density was calculated in pounds per cubic foot. Samples of hay were taken from the test bales, weighed, and placed in a drying oven. After the samples stopped losing weight (approximately 24 hr), they were removed from the oven and weighed again. The loss in weight was the water in the original sample. From the two weights the moisture content was calculated on a wet basis.

DISCUSSION OF CONNECTING-ROD FORCES

More energy is required to compress the material than to perform all the other functions of the baler. This energy must be transmitted through the crank arm and connecting rod; therefore, the forces on the connecting rod will be discussed in detail.

A typical connecting-rod force-time record is shown in Fig. 3. The extreme forward position of the plunger can be identified on the record by a small abrupt change in the force midway between the peak forces. This change in force is equal to twice the frictional force on the plunger. When the plunger is near its extreme forward position, only the friction and acceleration forces of the plunger act upon the connecting rod. The friction force is equal to 60 lb and was determined by pulling the plunger back and forth in the bale chamber. Before the plunger reaches its forward dead center position, the friction opposes the acceleration force. After the plunger has started to move in the other direction, the friction adds to the acceleration force. Therefore, the total change in the force at the forward dead center position was approximately 120 lb. The acceleration forces on the connecting rod, due to the reciprocating motion of the plunger, was about 135 lb.

At the 90-deg position of the crank arm the force on the connecting rod changes to tension. The positions of the crank arm as used in this paper are shown in Fig. 4. This tensile force was caused by the sudden stopping of the feeder head after it had been raised out of the bale chamber. At this time there is a large compressive force in the short connection which acts on the connecting rod causing an apparent tensile load to be recorded.

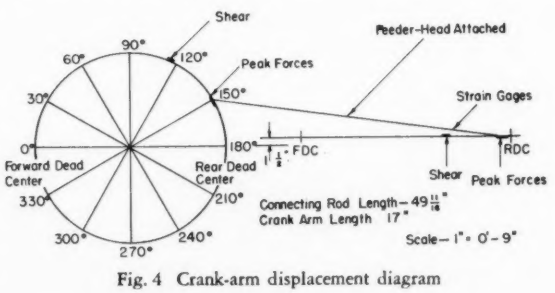

Fig. 4 Crank-arm displacement diagram

The feeder head does not completely separate the material it pushes into the bale chamber from that in the supply chamber. To divide the hay easily, knives are placed on the plunger to separate the material just before it is compressed. Shearing occurred on the test baler at 115 deg of crank-arm rotation past forward dead center position. The shearing force was low compared to the peak compression force. At the time shear occurs the press plate has little force on it from compressing the hay; therefore, the torque at the time of shear was about one-fourth of the peak torque for compression. On some balers shear occurs just before the peak compression, and the combined torque is higher than that due to the peak compression.

At high baling rates the compression forces start to build up on the press plate as soon as shearing has taken place. The total force of the press plate increases rapidly after shear until the material already compressed in the bale chamber begins to move through the tension controls. After this motion takes place, the force drops slightly as the plunger approaches its extreme rearward position. For a short distance after the plunger has started moving forward the hay still exerts a force on the plunger. This force is present for about 20 deg of rotation of the crank arm after the plunger has reached its extreme rearward position. For the remainder of the cycle only the friction and acceleration forces are present.

From representative cycles of the force-time curve, the connecting-rod forces were determined at every 10 deg of crank-arm rotation. The forces were then converted to torque on the crank, and a crank-arm torque-displacement curve plotted. This was done for three or four revolutions of the crank in each test run. The torque displacement curves were then planimetered to determine the average torque and horsepower. A typical torque displacement curve is shown in Fig. 9 and will be discussed later.

The tests of the connecting-rod forces in wheat straw and alfalfa will be discussed separately, since the two crops have different characteristics. Also, the tests in the two crops furnished information on different variables affecting the characteristics of the connecting-rod forces.

Wheat Straw

Tests were conducted at several rates of baling at each of a number of tension control settings. A curve of the bale density as affected by the baling rate for one tension setting is shown in Fig. 5. In all test runs the bale density increased with the baling rate in a similar manner. This increase in density was evidently caused by an increasing frictional

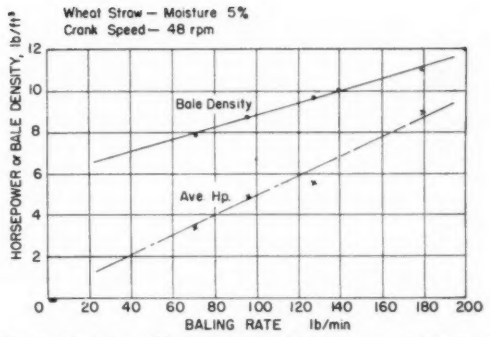

Fig. 5 Variation of bale density and horsepower with baling

resistance to the motion of the straw through the bale chamber. There are two things that may explain the increased resistance. One is that the friction may vary with the velocity of the material passing through the tension controls. The other explanation is that increased lateral expansion of the straw on the sides of the bale chamber raises the normal pressure on them, with a resultant increase in the frictional resistance.

The governor on the engine was adjusted in three positions to run the crank at 38, 48, and 55 rpm. Tests were conducted at each of these speeds to obtain the effect of crank speed on the peak forces. The forces at 160 deg have been plotted in Fig. 6 for each of the crank speeds at various rates of baling. The force at 160 deg was selected for plotting since it was approximately equal to the maximum force in all test runs and the peak torque occurred at 160 deg.

In the tests from which the data for Fig. 6 were obtained, the bale density increased with the baling rate. The actual bale density was approximately 9.5 lb per cu ft between the baling rates of 90 and 140 lb per min. From the curves, it may be noted that the force increases more rapidly at the slower speeds. Due to this rapidly increasing force and the decreased amount of kinetic energy in the flywheel, high baling rates could not be obtained at the slow crank speeds. Either the velocity of the plunger or the increased amounts of material per stroke of the plunger could have caused the more rapid increase in the force at the slow speed.

To determine the effect of crank speed upon the peak forces a curve was plotted from the curves in Fig. 6. This curve plotted in Fig. 7 shows the effect of crank speed upon the peak force while baling a constant amount of material

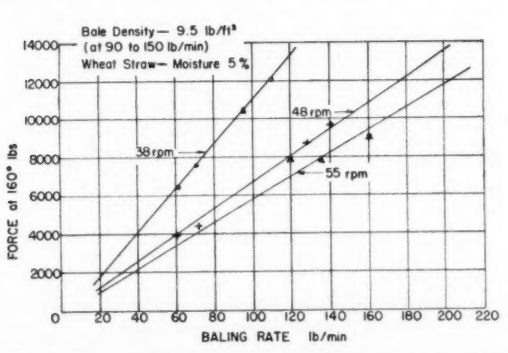

Fig. 6 Force at 160 deg with 38, 48 and 55 rpm of the crank

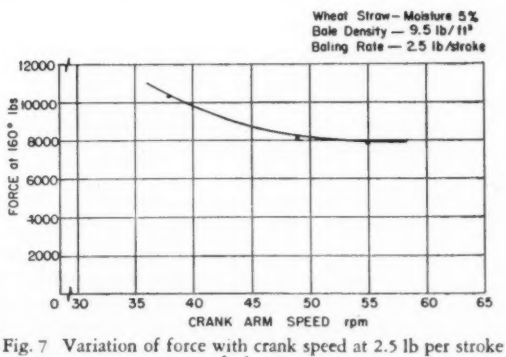

Fig. 7 Variation of force with crank speed at 2.5 lb per stroke of plunger

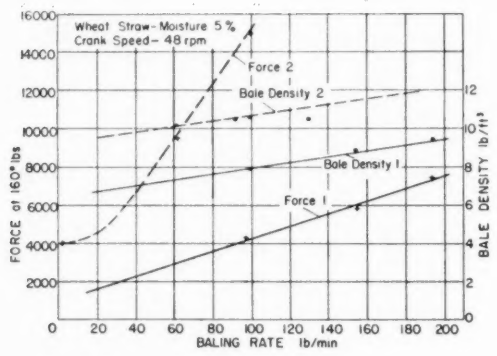

Fig. 8 Force and bale density at two tension settings

per stroke of the plunger. Up to 50 rpm the force decreases, but tends to level off above this speed. For a given amount of material per stroke of the plunger, there is little advantage in using a crank speed above 55 rpm. The effect of different crank speeds on the force at a constant baling rate can be easily determined from Fig. 6.

Another variable that affects the magnitude of the peak force is the rate of baling. Since the bale density increased with an increase in baling rate for a given tension-control setting, both bale density and force at 160 deg have been plotted in Fig. 8 for two settings of the tension control. At each tension setting, the bale density increased as well as the force at 160 deg. The rate of increase in the force was greater at the higher levels of bale density. From the rate of increase of the force at the higher tension setting it is evident that high baling rates at such a high density would be impossible to obtain on the test baler. It will also be noted that high baling rates could be obtained at low bale densities without causing excessive forces on the connecting rod.

Additional information may be gained by converting the forces on the force-time record to torque on the crank arm. A curve of the crank-arm torque for the maximum load cycle measured is shown in Fig. 9. Information concerning the conditions under which the data were obtained has been recorded on the curve. This torque curve can be used to determine the required size of the flywheel to limit the speed variation to a reasonable value.

In Fig. 9 the increase in torque from zero to 80 deg is due to the acceleration and friction forces. At 90 deg the torque decreases due to the effect of stopping the feeder head after it has been withdrawn from the bale chamber. Next a peak occurs in the torque curve due to the energy required to shear the straw. The magnitude of this peak is dependent upon the amount of material that needs to be cut each cycle.

After the hay has been sheared, the press plate begins to compress the hay and the torque on the crank arm rises rapidly. The torque peaks at approximately 150 deg and then drops rapidly. The decrease in torque is a combination of a lower force after 160 deg and the diminishing torque arm. For a short time after the plunger reaches its rearward position and starts moving in the opposite direction, the hay helps push it forward. This causes a negative torque and a small amount of energy is gained from the compressed hay. There was a definite increase in the energy obtained from the compressed hay as either the baling rate or bale density was increased. A positive torque was then required to accelerate the plunger toward the forward end of the bale chamber. As the plunger nears its forward position it slows down adding a very small amount of energy to the other parts of the baler. From the torque-displacement curve one can obtain the maximum and minimum horsepower, and by measuring the area under the curve the average horsepower may also be determined. Also the slowdown in the flywheel may be calculated as shown below.

Assuming that the engine is supplying 11 hp to the crank arm during the compression cycle, all the energy required above the average must come from the flywheel. The average of 11 hp is obtained from 9 hp for the crank arm and 2 hp required by the auxiliary drives. During the compression cycle little energy is being supplied to the auxiliary drives, so it is assumed that the total of 11 hp is being used to compress the material, and the governor has not responded to increase the output of the engine. Simultaneous records of the engine and flywheel characteristics show this assumption to be true.

The average torque on the crank arm at 11 hp would be 14,800 lb-in. The area beneath the torque curve above 14,800 lb-in was 3.60 sq in. Each square inch of this area represents

$$20{,}000\ (40)\ 2\pi/360 = 14{,}000 \text{ in-lb of energy.}$$

The energy that was supplied by the flywheel was

$$360 \times (14{,}000/12) = 4200 \text{ ft-lb}$$

The decrease in the velocity of the flywheel can be determined from the equation

$$\Delta KE = \tfrac{1}{2} I (W_o^2 - W_f^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

Solving the equation for the final velocity

$$W_f^2 = W_o^2 - (2\Delta KE/I) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

$\Delta KE = 4200$ ft-lb

I = mass moment of inertia of the flywheel = 12.8 ft-lb-sec^2.

Assuming that the crank arm is rotating at 48 rpm as the compression starts,

W_o (of the flywheel) $= 48 \times 9 = 432$ rpm

$W_o = 432 \times (2\pi/60) = 45.2$ radians per second.

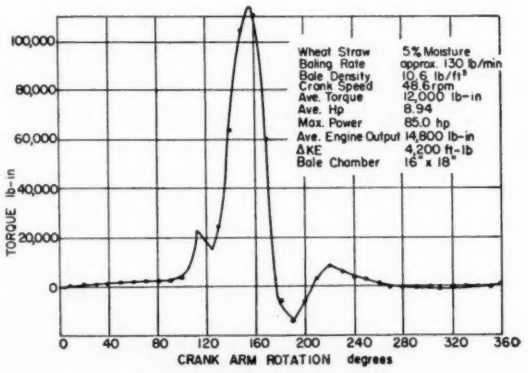

Fig. 9 Torque curve for highest load cycle measured

Substituting these values into the equation for the final velocity, we obtain

$$W_f^2 = 45.2^2 - \frac{2(4200)}{12.8} = 2040 - 657 \quad . \quad . \quad . \quad [3]$$

$$W_f^2 = 1383 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

$$W_f = 37.2 \text{ radians per second} = 355 \text{ rpm} \quad . \quad . \quad [5]$$

$$W_f \text{ of crank arm} = 355/9 = 39.4 \text{ rpm} \quad . \quad . \quad . \quad [6]$$

Decrease in speed of the flywheel = (432—355)/432 = 17.8 percent.

The maximum slowdown should not exceed 20 percent allowing 10 percent slowdown of the engine and 10 percent for belt slippage. Since this was the maximum load that could be obtained without the clutch slipping, there would be no need to increase the speed and size of the flywheel without an increase in the clutch capacity. If the clutch capacity were increased, the speed or moment of inertia of the flywheel should also be increased. From Fig. 3 it appears that the clutch slipped a little between 160 and 170 deg. During several runs the clutch slipped at torques below 112,000 lb-in, and all the energy of the flywheel was dissipated in the clutch.

To check this method of determining the slowdown of the flywheel a crank-arm velocity-displacement curve was plotted. The velocity was calculated for each 10-deg interval by measuring the distance between the 10-deg marks and converting it to crank speed. Since the clutch had slipped between 160 and 170 deg, Fig. 3 could not be used. Therefore, the velocity curve was plotted for the next highest load cycle and is shown in Fig. 10. The minimum speed was calculated from the torque curve (by the method shown above) and found to be 4.35 radians per second. From the velocity curve the minimum speed was 4.38 radians per second. The flywheel speed decreased 14 percent during the compression cycle. During this cycle a total of 3860 ft-lb of energy was supplied by the flywheel to compress the material as compared to 4200 ft-lb for the maximum-load cycle obtained.

Several different crank-arm and connecting-rod lengths are used on commercial balers at the present time. Therefore, it is desirable to give the data in a form that can be used with reasonable accuracy on other balers. The method selected for this was the press-plate force-displacement diagram, since it represents the most basic information obtained on the compression forces. The procedure described below was used to obtain the press-plate force-displacement diagrams.

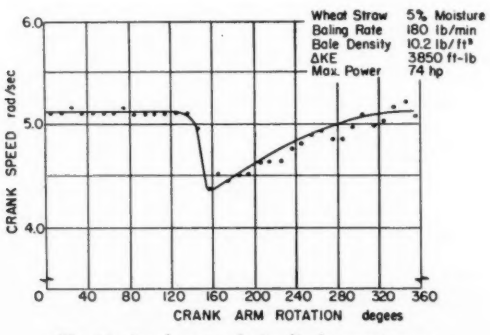

Fig. 10 Crank-arm velocity-displacement curve

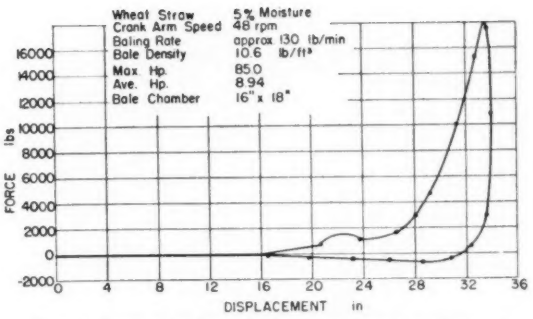

Fig. 11 Press plate force-displacement curve for maximum load cycle

The acceleration forces on the connecting rod caused by the plunger were determined by first plotting a curve of the plunger acceleration against crank-arm rotation. From the relation $F = ma$, the acceleration forces of the plunger on the connecting rod were calculated. By removing the connecting rod from the plunger and pulling it back and forth in the bale chamber the friction force on the plunger equal to 60 lb was determined.

By subtracting the acceleration and friction forces from the connecting-rod forces recorded in Fig. 3, the actual force on the press plate may be determined. A curve of the press-plate force versus linear displacement has been plotted in Fig. 11. The rise in the curve at 23 in displacement is caused by shear and will vary with the amount of material being cut. The remainder of the curve is the compression force since friction and acceleration have been subtracted from the measured force.

Under the same conditions the forces on the press plate of another baler should vary from those in Fig. 11, only by the position and magnitude of the shearing force. On most balers the shear occurs nearer the end of the plunger stroke and adds to the compression force. If shear takes place near the end of the stroke, it may result in higher forces due to a slower knife speed. Also each baler has a different feed mechanism. The one on the test baler pushed the material into the compression chamber so that a relatively small amount of material had to be cut. On other balers a much larger amount of material has to be cut. With all these variations, the shearing force can be estimated to be about one-fourth the peak compression force, and when placed at the proper displacement will result in a good approximation since the energy required for shear is small compared to that for compression.

The force-displacement curve is actually a work diagram. When using this curve to plot the torque on the crank arm of another baler, one should obtain approximately the same average torque if friction and acceleration have been added and the bale chambers have the same cross-sectional area. This would be true for any crank arm since Fig. 11 is a work diagram and one cannot change the energy required by a change in crank-arm and connecting-rod arrangement. Forces on the press plate of another baler might vary from those in the curve due to a difference in the velocity of the press plate, but if an allowance is made for the speed of the crank and the size of the bale chamber, the results should be close enough for design purposes. If the torque is being determined for a 15-in crank, only the forces between the

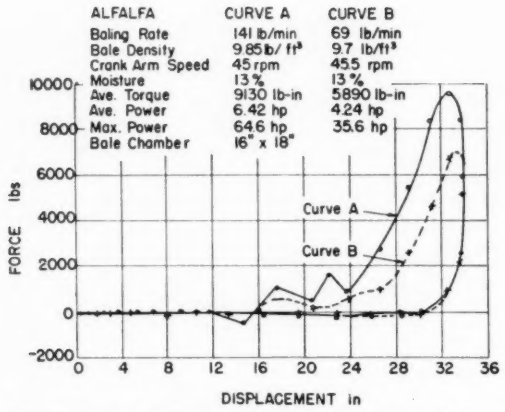

Fig. 12 Press plate force-displacement diagrams in alfalfa

displacement of 4 and 34 in should be used since the displacement between 0 and 4 in does not occur with a 15-in crank arm.

The peak force occurs just before the hay already compressed in the bale chamber starts to move through the tension control. After this happens the force drops slightly as the resistance reduces from static to sliding friction. The curve plotted in Fig. 11 shows that the hay did not start to slide through the tension control until the plunger was within 0.5 in of its extreme rearward position. After the plunger reaches its extreme rearward position, the hay tends to push the plunger forward and causes the positive force between 34 and 32 in displacement on the return stroke. This corresponds to the negative torque between 180 and 210 deg on the torque curve in Fig. 9.

A torque curve plotted from the work diagram will give the peak torque required and show the relation between the peak shear torque and peak compression torque. If the shear occurs near the extreme rearward position of the plunger, the combined shear and compression torque could easily be higher than the peak compression torque. In calculating the horsepower required for another baler under the same conditions an allowance should be made for the speed of the crank arm. Also a correction should be made for the bale chamber size and the baling rate since the curve is good only for 130 lb per 48 rpm = 2.7 lb per stroke of the plunger.

Even though the discussion in this section is devoted to the tests in straw, a short discussion on the energy curve in alfalfa will be given here to complete the discussion on press-plate force-displacement diagrams. This discussion will show that the energy curve can be used on other balers with accuracy suitable for design purposes.

Two work diagrams have been plotted in Fig. 12 from data obtained in the alfalfa tests. Both curves were obtained in alfalfa at the same moisture content and approximately the same bale density. The principal difference in the curves is the baling rate at which they were obtained. Both curves exhibit the same characteristics and differ only in magnitude. The compression force increases at the same rate on both curves, but the increase occurs later and is not as large for the low rate as it is for the higher rate. Since the magnitude of the force on the return stroke is dependent more upon the bale density and properties of the compressed materials than upon the baling rate, the two curves almost coincide on the return stroke.

To determine if it is feasible to use the work diagrams from the test baler as basic information for other balers, a work diagram taken from tests on an International Harvester 45-T baler was plotted in Fig. 13 along with curve B of Fig. 12. The tests on the 45-T baler were conducted in the laboratory with wheat straw, but the baling rate and bale density were not recorded. Even though the curves are from different balers, they are very similar in appearance. The main difference in the two curves is the position at which shear occurs. Another noticeable difference is the magnitude of the forces on the press plate as the plunger starts its forward motion after compressing the hay. The difference could have been caused by different stops and wedges in the bale chamber or a difference in the properties of the compressed material.

The above discussion shows how the press-plate force-displacement curve can be used on other balers with accuracy suitable for design purposes. In view of the importance of the curves, the press-plate forces at each 10-deg interval between 130 and 190 deg were plotted against bale density for each test run in wheat straw at 5 percent moisture and baling rates around 100 lb per min. At most of the angles the plotted points fell in an organized manner through which a curve could be drawn. Statistical methods were used to draw the curve through the points on the force curve at 170 deg. The equation chosen to be fitted to the data was of the form $y=ax^b$, where y is the magnitude of the force and x is the bale density. By an analysis of the data the constants $a=2.391$ and $b=3.656$ were determined. The equation for the curve at 170 deg became $y=2.391\times3.656$. This curve was then plotted along with the measured data. The index of correlation was found to be 0.88 for this curve. The procedure for determining the constants a and b and the index of correlation can be obtained from an advanced statistics text.

This same statistical procedure could have been used on the data for the other angles, but the results obtained did not seem to warrant the effort involved. Therefore, a freehand curve was drawn through the data and an index of correlation determined for the curve at each angle. The curves for the angles between 130 and 190 deg are shown in Figs. 14 to 20. The forces outside of the range between 130 and 190 deg are primarily due to shear, inertia and friction. To plot a press-plate force-displacement diagram for another baler the inertia and friction forces would have to be determined before the complete diagram could be drawn. In

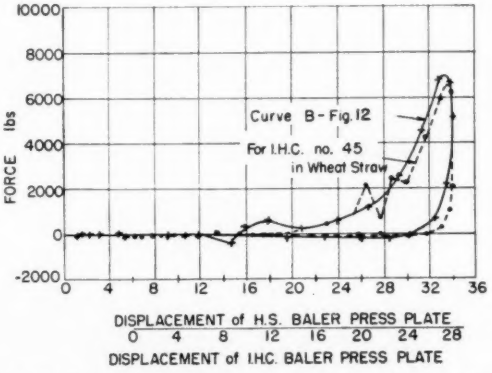
Curve B - Fig. 12
For I.H.C. no. 45
in Wheat Straw
FORCE lbs
DISPLACEMENT of H.S. BALER PRESS PLATE
DISPLACEMENT of I.H.C. BALER PRESS PLATE

Fig. 13 Press plate force-displacement diagrams for two balers

order that the curves may be applied to other balers the distance of the press plate from its rearward most position is also given on each curve.

From the rapid rate of increase in the magnitude of the forces above a bale density of 10 lb per cu ft, it appears that bale densities about 11 lb per cu ft would be almost impossible to obtain at a rate of 100 lb per min. In conducting the tests this was found to be true. At the high bale densities the baling rate was very critical, and a slight increase in the rate resulted in torques above the capacity of the clutch in the flywheel.

In using the curves it must be remembered that they were obtained with straw at 5 percent moisture. In actual field conditions the moisture content of the straw will be somewhat higher than the test conditions. If curves had been obtained with straw at other moisture contents, they would

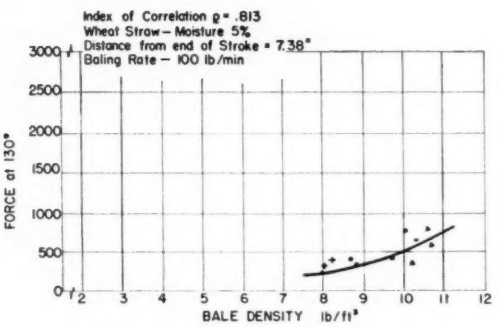
Index of Correlation ρ = .813
Wheat Straw – Moisture 5%
Distance from end of Stroke = 7.38"
Baling Rate – 100 lb/min
FORCE at 130°
BALE DENSITY lb/ft³

Fig. 14 Force at 130 deg versus bale density

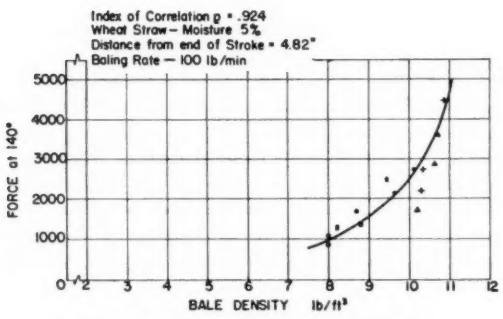
Index of Correlation ρ = .924
Wheat Straw – Moisture 5%
Distance from end of Stroke = 4.82"
Baling Rate – 100 lb/min
FORCE at 140°
BALE DENSITY lb/ft³

Fig. 15 Force at 140 deg versus bale density

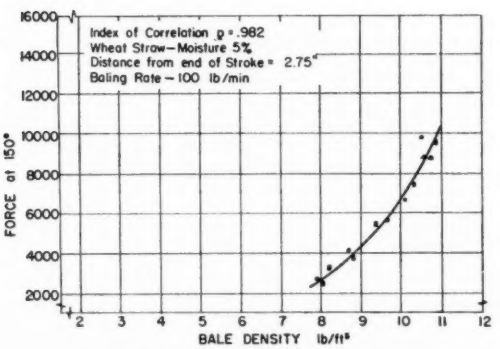
Index of Correlation ρ = .982
Wheat Straw – Moisture 5%
Distance from end of Stroke = 2.75"
Baling Rate – 100 lb/min
FORCE at 150°
BALE DENSITY lb/ft³

Fig. 16 Force at 150 deg versus bale density

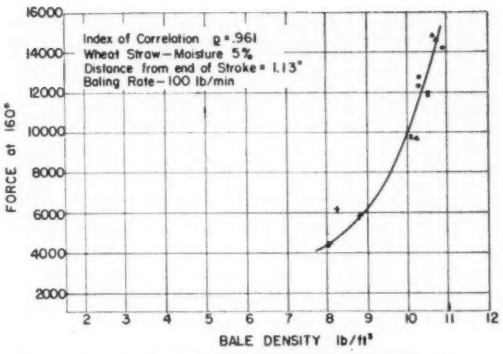
Index of Correlation ρ = .961
Wheat Straw – Moisture 5%
Distance from end of Stroke = 1.13"
Baling Rate – 100 lb/min
FORCE at 160°
BALE DENSITY lb/ft³

Fig. 17 Force at 160 deg versus bale density

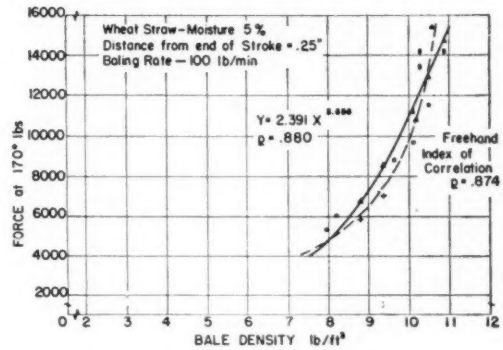

Fig. 18 Force at 170 deg versus bale density

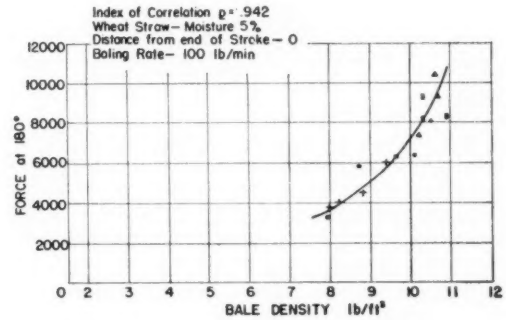
Index of Correlation ρ = .942
Wheat Straw – Moisture 5%
Distance from end of Stroke – 0
Baling Rate – 100 lb/min
FORCE at 180°
BALE DENSITY lb/ft³

Fig. 19 Force at 180 deg versus bale density

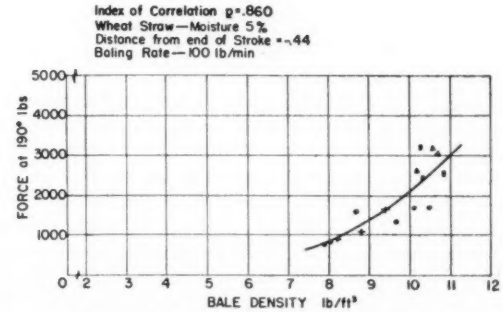
Index of Correlation ρ = .860
Wheat Straw – Moisture 5%
Distance from end of Stroke = .44
Baling Rate – 100 lb/min
FORCE at 190° lbs
BALE DENSITY lb/ft³

Fig. 20 Force at 190 deg versus bale density

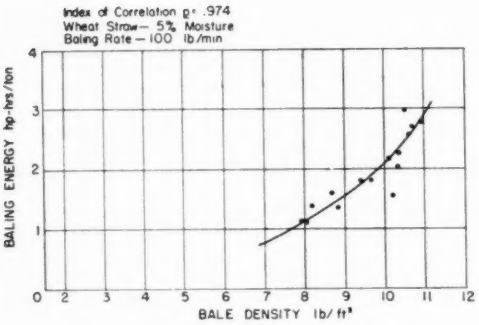

Fig. 21 Effect of bale density upon baling energy

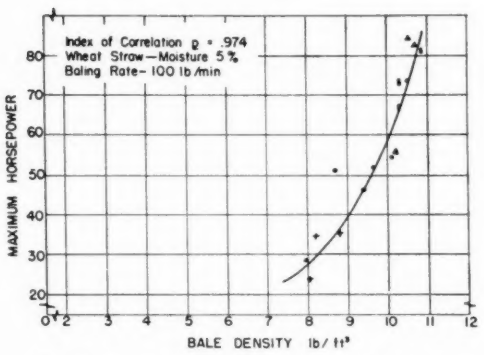

Fig. 22 Maximum horsepower versus bale density

probably have exhibited similar characteristics. They might have been displaced somewhat as to bale density. The rate of increase of the force, as the limiting bale density was approached, would probably have been less than for the curves in Figs. 14 to 20.

To make a complete analysis of these forces, similar curves would have to be plotted for at least four baling rates in each of four different moisture contents. This would then need to be repeated for different crank speeds. If all this data were available, it would then be worth while to fit curves of the form $y=ax^b$ to the data. After the constants a and b were determined for each condition, curves showing the effect of moisture content, baling rate and crank speed upon these constants at several positions of the press plate could be drawn.

From such a set of curves one could determine a and b at a given position of the press plate for any combination of moisture content, baling rate, and crank speed. By substituting these into the equation $y=ax^b$, the expected force (y) for a selected bale density (x) at that position of the press plate could be determined. The force-displacement diagram could then be drawn for any condition by repeating this for several positions of the press plate.

Many hours of careful field testing and analysis would be necessary to complete the above analysis. The expense involved would probably be greater than the benefits obtained. The most economical approach would be to determine the general effects of moisture content, baling rate, bale density and crank speed on these forces along with a maximum-load condition. From the general effects of the variables, one can determine if it is feasible to try and bale under certain conditions. The size of the flywheel, crank arm, and connecting rod may be determined from the maximum-load condition. The method for calculating the slowdown of the flywheel has already been given and the size of the crank arm for the maximum measured torque may be determined by usual design procedures.

Even though the information regarding the factors influencing the press-plate forces are not complete, the information presented can be used until more complete data are obtained. Designers can use the information presented to estimate the forces on the press plates of other balers under a limited number of conditions. In many cases the maximum measured load cycle presented in Fig. 11 will be sufficient.

Fig. 21 was plotted to show the effect of bale density upon the energy required to bale a ton of material. The energy requirement increases as the bale density goes up, but the rate of increase is much higher at the higher bale densities than at the low bale densities. As far as power requirements are concerned the baling should be done at a low bale density. However, in some cases the bales must have a high density so that it will be easier to transport them. Curves of the energy per ton of material at different crank speeds did not show any definite trend.

A curve showing the effect of bale density upon the maximum horsepower is shown in Fig. 22. This curve was obtained from the same test runs as Figs. 14 to 20. Bale densities above 11 lb per cu ft could not be obtained since it would require exceeding the maximum horsepower (85) the clutch would transmit.

Alfalfa

One objectionable feature of present balers is the variation of bale density with a slight change in the moisture content of the hay. The moisure content may vary 5 to 10 percent from one part of the field to another just from a difference in the yield at the two points. When going from the dry to the wet material, the bale weight always increases, so tests were conducted to determine if this increase was due to moisture alone or partly due to an increase in dry matter. From these tests three curves have been plotted in Fig. 23.

Curve A is the bale density as baled when going from one moisture to another without changing the tension controls on the baler. As the moisture increased, the bale density also increased because of the rising friction force and the weight increase caused by the moisture. Curve B is the bale density required to maintain the same amount of dry matter in the bale as that baled at 20 percent moisture.

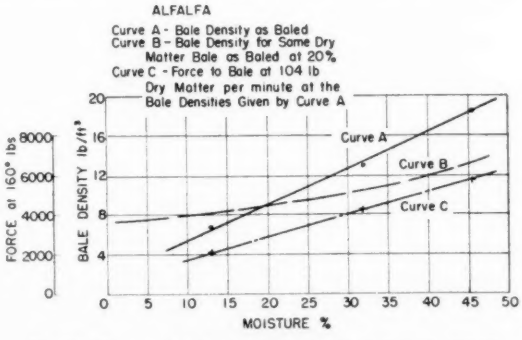
ALFALFA
Curve A - Bale Density as Baled
Curve B - Bale Density for Same Dry Matter Bale as Baled at 20%
Curve C - Force to Bale at 104 lb Dry Matter per minute at the Bale Densities Given by Curve A
FORCE at 160" lbs
BALE DENSITY lb/ft³
MOISTURE %
Curve A
Curve B
Curve C

Fig. 23 Force and bale density at constant tension setting

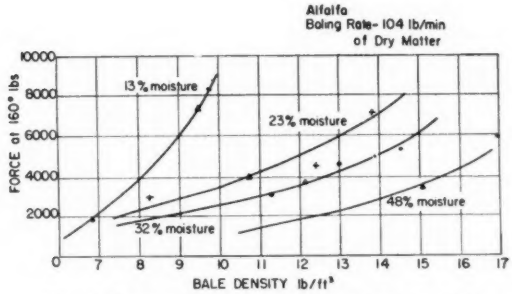

Fig. 24 Force at 160 deg versus bale density in alfalfa

The ideal condition would be for curve A to coincide with curve B and then the bales would all have the same weight after completely drying.

The force at 160 deg with a constant tension setting has been plotted in curve C for the same test runs as plotted in curve A. The force to compress the hay increases because of the larger friction forces on the bale chamber and results in more dry matter per bale.

The force at 160 deg of crank rotation at the four moisture contents has been plotted against bale density in Fig. 24. Only a few points are available for these curves, but on the basis of the curves in Figs. 14 to 20 it is felt that it would be best to draw the curved lines realizing that they may not be accurate. These curves are given only to show the trend and not as proven relationships. Several more points should be obtained before a definite relation can be established. As the moisture content was increased, the bale density obtainable with the baler also increased; that is, only low bale densities could be obtained with the dry hay and only high bale densities could be obtained at the high moisture contents.

Total Auxiliary-Drive Requirements

The greatest variation in the power transmitted to the auxiliary drives was from the action of the feeder head and plunger. As the feeder head is pulled out of the bale chamber it is given a high initial acceleration. This high acceleration increases the necessary output of the flywheel and lessens the torque available for the auxiliary drives. After the feeder head has been raised out of the bale chamber, its upward motion is stopped as quickly as it was started. This requires other parts of the baler to absorb a large quantity of energy to decelerate the feeder head. A portion of the energy is absorbed by the auxiliary drives, causing a peak in the torque transmitted through the crank arm. The torque input to the auxiliary drives is again lowered as the hay is being compressed by the plunger. The torque level for the remainder of the revolution is dependent on what is required to overcome the resistance in the various units.

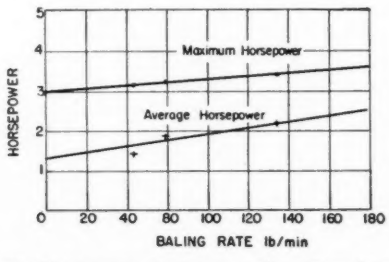

Fig. 25 Total power requirements of auxiliary drives in wheat straw

Noticeable changes occur in the torque curve during a tying cycle. The effects of the acceleration and deceleration of the feeder head are still prominent, but the effect of compressing the hay is hardly noticeable. At the time the hay is being compressed a large torque is required to drive the shuttles into the bale chamber. The torque suddenly drops to a low level and then increases slightly as the wire is twisted. As the wire is cut and bent back a high torque is required for a short period. Again a high torque level is required to draw the shuttles out of the bale chamber.

As the rate of baling increases the average power required by the auxiliary drives increases gradually. This is shown in Fig. 25 where the maximum and minimum horsepower requirements have been plotted against baling rate. Table 1 gives the maximum, minimum, and average horsepower required by the auxiliary drives in three crops. The requirements at no load are also given in the table. The maximum horsepower is the peak measured for the test run and should be used for design purposes.

TABLE 1. TOTAL REQUIREMENTS OF THE AUXILIARY DRIVES

Baling rate, lb per min	Material baled	Shaft speed, rpm	Horsepower Maximum	Minimum	Average
200	Clover	45.5	4.27	0.33	2.10
180	Wheat straw	46.0	3.51	0.15	2.50
200	Alfalfa	46.5	4.10	0.20	2.35
200	Alfalfa (tying cycle)	46.5	5.20	0.70	2.50
No load		46.0	3.10	0.40	1.35

SUMMARY

The material presented in this paper shows the effects of the variables which are of primary importance in the operation of a plunger-type forage baler, namely moisture content, bale density, baling rate, and plunger speed.

The moisture content is a factor which to date has provided many innovations to control its effect. It is apparent that the primary cause of variable bale density is the change in friction as the moisture content varies. As the moisture content increases the friction becomes greater through the range of normal baling moistures. This serves to amplify the change in bale density over that which can be attributed to the increased amount of moisture in the bale.

One of the factors by which a baler is judged is its ability to produce a bale of high density. This is especially true if the bale is made for the commercial market. There is a strong possibility that the farm machinery manufacturers and the custom and farm operators are entering into a phase where they are not obtaining the most value from the present baler. As shown in the paper, for an increase from a bale density of 8 lb per cu ft to 10 lb per cu ft the maximum force increased from 4500 to 10,000 lb and the baling energy increased from 1.2 to 2.2 hp-hr per ton. This means that for only a 14-lb increase in a 7-cu-ft bale we must pay almost twice as much on an energy basis. As the bale density is increased further, the plunger forces become prohibitive. Even though the rate is decreased to allow the flywheel to have enough carry-through, the high forces are present causing a decreased machine life. The strawboard industry has set up a standard for a satisfactory bale. It might be well for those interested in commercial forage baling to try to set up also a suitable standard for hay. *(Continued on page 232)*

What Farmers Want and Need in Tractors and Implements

Paul C. Johnson

THE productivity of American agriculture has rested chiefly on three things: persistent research in agriculture and remarkable success in translating research into practice by educational means, a high degree of curiosity and aptitude on the part of the farmer himself, and a strong drive for better and better farm machinery.

Our good machinery has come to us largely because of persistent research and aggressive salesmanship by industry. In this respect progress in mechanization has been somewhat different from progress in crops and livestock, where the leadership has been taken by land-grant colleges in both research and education. Agricultural colleges and mass media such as the farm magazines can be credited with a strong assist in bringing about mechanization on the farm, but they have not led the way.

Last year, I had occasion to make an investigation of the farmer's attitude toward the machinery he is getting and the relation of industry research and college research to machinery improvement. We prepared a rather comprehensive questionnaire which was filled out by approximately 500 boys in FFA high school classes and 500 active farmers. I also discussed the problem at considerable length with agricultural engineers in the colleges and on the staffs of implement companies.

As a result of this investigation I arrived at two general conclusions: One is that we need more fundamental research in the farm implement field. We need to tackle the defects in our modern farm machinery with what Aristotle called a "tough mind." The colleges can dig out certain basic information which can be of great value to the engineer working in product improvement in company laboratories. In spite of vast expenditures of funds and feverish competition to make a "better mousetrap," many needed improvements in farm machinery are long postponed. Farm machinery companies could save a lot of money for themselves and for the farmer if the agricultural-engineering divisions of land-grant colleges could expand their programs.

A second conclusion that I arrived at was that there is too wide a gap between the agricultural engineer and the farmer. I was amazed to find how few are the people in the farm machinery industry who have actually tried to find out what the farmer wants and what he will need in future years.

Nobody can tell you better what the farmer wants than the farmer himself. It is not enough to depend on the dealer to pass on the reaction of farmers. Dealers have a way of getting snarled up in their sales problems.

I should say at this point that dealers are taking a more intelligent interest in farming. In this respect there is no comparison between the dealer today and the dealer 20 years ago. But we need a degree of training and objectivity in approaching the farmer which we have no right to expect from a dealer setup. You can spend a million dollars developing a superb farm machine and still forget to provide a place where the operator can put his feet. This is happening every day in our machine development.

What does the farmer want in his machinery? We found out, somewhat to our surprise, that he wants a complete machine, and he is willing to pay for the extras. Every engineer knows that a lot of gadgets are sold and attached to tractors after they are delivered to the farm. I have a new respect for these gadgets after asking a thousand farmers and farm boys what belongs on a farm tractor. Nobody wants a tractor now without a self-starter. A power-takeoff clutch or its equivalent is considered a necessity. So are lights, extra-comfortable seat, and many other gadgets that we have considered to be unnecessary accessories. It may be that lower farm incomes will reconcile farmers to buying a stripped-down tractor and saving several hundreds of dollars, but I doubt it very much.

If you will study this strong urge for improvements and accessories you will find that they have pretty sound reasons. They are grounded in a need to save labor and to eliminate fatigue. Most tractor operators are not healthy young athletes in the prime of life. They are more likely to be women and boys and older men plagued by rheumatism or a sagging sacroiliac.

I am personally very much interested in the fatigue factor in tractor operation. We know it has a close relationship to the accident rate. Our survey revealed that the older men regard driving a tractor as just about the hardest job on the farm. Hard steering is a common complaint. So is noise and bad air. The farmers who answered our questionnaire estimated that in an average day's work you got off and on a tractor about 20 times. Some of our tractors have been about as easy to mount as a bucking bronco, and you can bet that such a defect will lose sales in the long run.

The trend toward hydraulic controls, attached implements, and quick hitches was absolutely inevitable. Nor can we get by with such devices for only the small tractor. As we build them bigger, we are going to have to put the same labor-saving devices on the big tractors as on the little ones. The big ones need them that much more. I will not dwell on which gadgets are most important to the farmer because my information is already out of date. Every agricultural engineer should have his own contacts and should carry on a continuing investigation.

In our questionnaire we asked farmers and farm boys what they considered most important in a tractor, speed and power, fuel economy, or long life. Evidently they want snappy performance because speed and power won by almost two to one over the others. Oddly enough, the boys and the men voted alike in this decision.

A common complaint was that tractors are often overrated when sold. Nobody knows better than the farmer

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the value of extra power in a pinch, and farmers are surprisingly aware of the danger of abusing a tractor by constant overloading.

Incidentally, farmers think that the tractor and the plow are the best engineered implements now being built for farm work. The machines which they think need the most improvement are the combine and the cornpicker.

Our investigation indicated that farmers are looking far ahead. When asked which would be the tractor fuel of the future, diesel, LP gas, or gasoline, they put diesel fuel in first place, LP gas second, and gasoline third, even though 95 percent of them are using gasoline at the present time. They are going to be asking you soon for power steering, some kind of automatic transmission, better brakes, better control of attached implements, and larger machinery that will do better work at higher speeds. Many asked how soon they could expect a gas-turbine engine.

You can be sure of one thing. As you develop these new improvements, the farmer and his son will be right on hand to look them over and quick to buy if there is reasonable assurance that the new design will do a better job.

The hunger for better machinery is an established fact with the American farmer. Right now the industry is talking about "controlled obsolescence" as a means of spurring more sales. I would rather skip the fancy phrases and suggest that there is plenty of room for improvement in adapting our machinery to present farm practices, and farm practices are changing so fast that we will never catch up.

Which brings us to my second and more important question. What does the farmer need in his machinery?

I am not ready to turn this over entirely to the economist who has frequently admonished the farmer about overbuying and getting too much money tied up in expensive machines that are idle most of the time. I have a lot of respect for the economist's point of view, but we all know that farmers have been overbuying consistently for many years and have made money.

We are beginning to suspect now why they have been able to do this so successfully. Over the years we have underrated such factors as timeliness and labor saving. We are beginning to suspect that some of the good weather of the past ten or a dozen years was not exceptional weather at all, but rather it was the farmer beating the weather with good equipment and better timing. He is consistently coming up with better crops in spite of the weather. Of course, it is hard to apply an accurate yardstick to this timeliness factor, but it seems likely that it has paid for a lot of new machinery in the last 15 years. Add this timeliness factor to the constantly increasing labor costs and you have the compelling reason why the modern farmer has become addicted to new and better machinery. He won't wait for a machine to wear out but will trade it for a machine of newer design just as soon as he feels he can afford it.

So we see that in some respects the farmer is ahead of his professional advisers. However, when it comes to gauging the future, the research man should have access to better information than the farmer himself. There is no good reason why we need to play these things by ear as we have done in the past.

If we get to the point of loading up the farmer with machinery he does not need, not even the machinery industry will profit. Our research people should be doing more work to get at the actual cost of machinery as related to its contribution to farming. Maybe this timeliness factor can be evaluated and put on paper to the extent that it will help us make intelligent decisions. We could use some well-grounded charts to help us compare the cost of labor performed by the machine with labor performed by the farmer and his family. I believe that with proper research some of these intangibles which we deal with can be made tangible.

Of course, there is a limit to the amount of machinery that a farm can carry. Mechanization tends to make farming a higher-volume business with a lower per unit profit. Agriculture is moving to a different level. We should be studying the implications of that change.

As we increase mechanization on our farms we must continue to streamline the mechanical operation. We must combine operations, increase the number of hours each machine can do useful work, and telescope the whole process of mechanical farming. For instance, we are beginning to suspect that we do not need to manipulate the soil as much as we have done in the past. Since this is one of our costliest operations, the engineer should join with the agronomist and the soil scientist in reducing cultivation to a minimum.

In designing machinery for the future, keep your eye on the wastes in farming. The farmer himself is not always conscious of these wastes, but he can pay for a lot of new machinery with 10 percent of the corn crop, or 15 percent of the soybean crop, or 40 percent of the hay crop. In many instances the change from land operation to machinery has increased rather than decreased those wastes. While we have made enormous savings in man-hours and improved our timeliness, we have made a big sacrifice in the amount of crop left in the field from which no cash income is realized.

In the past decade product design engineers of the farm equipment industry have made outstanding progress in the development of tractors and implements that farmers want and need. The J. I. Case equipment shown in these two views is typical of what they have accomplished

Of course, one of the wastes is the heavy toll of farm accidents and illness which can be traced directly to faulty operation of farm machinery, and in some cases to faulty machinery. We are doing a pretty good job getting at farm accidents but we have given very little thought to health difficulties that may be traceable to the machine.

Our farms are growing bigger, and the demand is for bigger machinery. You hear some talk that the family is done for and that we are moving into an era of corporation farming. Of course, this would have profound influence on the type of machines needed and the nature of the market.

I firmly believe that the family farm is here to stay and that you will be dealing, as in the past, with the personal decisions of the farmer and his boy rather than the purchasing department of a large corporation. But let's not forget that the family farm is bigger than it used to be and that the disappearance of horses has made it necessary for most farms to have more than one tractor. The urge to save farm labor by substituting machinery is strong even on this type of farm.

Some of our best agricultural economists are betting that the family farm will continue to be the pattern of the future. They point out that the family farm is actually an efficient operation, able to outdo the large corporation in many respects. The family farm makes up for its lack of size with the personal interest and willingness to do extra work on the part of the operator and the members of his family. The machinery industry has an enormous stake in keeping the family farm efficient.

I set out in the course of these remarks to make two points. One is that agricultural engineers should know more about actual farm operations and should know more about farmers, how they think and how they work. As a profession, you should do a systematic job of vitalizing this contact. It is not enough to depend on the information that filters through to you by guess and by gosh.

The other point is that with millions in research being expended toward the design of newer and better machinery, you people in the profession should consult the experts as to the pattern of agriculture for the future and the needs which the farmer himself does not yet suspect.

Our productivity in this country rests largely on our eagerness to substitute machine-made horsepower for manpower. There are always people who want to reverse this process. They want to turn men into machines rather than build machines to serve free men. Whether we will be permitted to build better machines in the future will depend on how wisely we build them now and how intelligently we apply the machines to their purpose of serving mankind.

Power Characteristics of a Forage Baler

(Continued from page 229)

It has been expressed that high baling rates result in a loss in bale tension. In over 75 different tests, the bale density always increased with an increase in baling rate. The increased bale density, coupled with the increase in material, causes a rapid increase in the amount of work per stroke. The mass moment of inertia of the flywheel may be increased to provide the necessary carry-through; however, the resulting bale usually has rather unsatisfactory characteristics.

Up to 55 rpm, the peak compression force decreases, but tends to level off above this speed. Since the baling energy is dependent upon the force, it also tends to level off. This means that the only gain will be in machine capacity if higher crank speeds are used. On a practical basis, the gain in capacity must be weighed against the additional design problem due to the higher speeds.

REFERENCES

1 Kinsman, C. D., Summary of the national farm power survey, AGRICULTURAL ENGINEERING, vol. 5, August, 1924, p. 176.
2 McCuen, G. W., Some power studies through use of the Ohio recording dynamometer, AGRICULTURAL ENGINEERING, vol. 5, March, 1924, pp. 51-55.
3 Hansen, Merlin, Loads imposed on power and take-off shafts by farm implements, AGRICULTURAL ENGINEERING, vol. 33, February, 1953, pp. 67-70.
4 Burrough, D. E., Experimental determination of power and torque distribution in farm machinery, Unpublished thesis, Purdue University, 1951.
5 Bennett, Charles A., Compression of cotton at cotton gins, AGRICULTURAL ENGINEERING, vol. 22, August, 1941, pp. 281-283.
6 Pearson, F. A. and Bennett, K. R., Statistical methods, John Wiley and Sons, 1949, p. 207.
7 Albert, C. D., Machine design drawing room problems, John Wiley and Sons, 4th edition, revised, 1951, pp. 87-88, 150-151.

Process Engineering Activity

A SURVEY of activity and interest in farm products processing in the state agricultural colleges, conducted by the ASAE Committee on Agricultural Processing—with 32 institutions reporting—produced the following summary of results; the figures show the percentage of institutions reporting research in the various areas indicated:

	Current and/or needed	Current*	Needed*
Crop drying and/or storage	69	56	34
Vegetable and fruit harvesting aids	31	25	16
Materials handling, crops	44	25	28
Canning plant and packing house operations	31	19	25
Food freezing and cold storage	22	16	13
Dairy products processing, farm and commercial	25	19	16
Livestock feed preparation	37	9	28
Seed processing	15	6	9
Poultry products processing	16	12	9
Other	16	12	9

*Many schools reported current research and more needed in the same area.

Average number of staff members spending more than one-third time on processing	1.4
Percent of average budget used for processing research	18.0
Percent of states offering a course in processing in the agricultural engineering curriculum	22.0
Percent of states not offering a processing course in the agricultural engineering curriculum, but indicating a need for one	22.0
Percent of states offering a course in processing for non-engineering students	28.0
Percent of states not offering a non-engineering course, but indicating a need for one	9.0

Attention is invited to the need for research activity in crop drying, fruit and vegetable harvesting and processing, materials handling, and feed preparation areas.

Contemporary British and European Tractors

Wayne H. Worthington
Fellow ASAE

(Continued from the March issue)

AT THE present time the Dagenham Works of the Ford Motor Company is in volume production of the Fordson Major tractor. This tractor is shown in Fig. 17. An especially narrow model is shown with a four-bottom side-cutting plow working in a hop field.

The engine used on the Fordson Major tractor is generally similar to the basic engine used in English-built Ford motor trucks. This four-cylinder, overhead-valve engine has five-bearing crank and camshafts, with a stroke of 4.524 in. The diesel and distillate-burning engines have a bore of 3.937 in and the gasoline engine a bore of 3.740 in. Compression ratios are 16 to 1 for diesel operation, 4.35 to 1 for distillate, and 5.5 to 1 for gasoline. The engines are all rated and tested at 1600 rpm. Aluminum cam-ground pistons operate in wet cylinder liners. A centrifugal ball-type governor is used on the gasoline and distillate engines and a pneumatic governor on the diesel engine.

The transmission provides six forward speeds, consisting of three speeds and reverse in each of two ranges. Travel speeds range from 2.07 to 13.16 mph at 1600 rpm engine speed. Two gear-shift levers are used, making gear shifting rather complicated. For instance, in shifting from second to third speed, it is necessary to operate both gear-shift levers.

Front-wheel tires are 6.00 x 19 and treads may be adjusted in 4-in steps from 49¾ to 73¾ inches. Rear-wheel treads with 11-36 and 11-38 tires may be adjusted from 52 in to 72 in. With 14-30 tires, the tread is 58 in and is not adjustable. The 14-30 and 11-38 tires are available for export only. The adjustable front axle is a steel casting.

Much attention has been given to the three-point implement attaching linkage which is built to the Category II British Standard and which is available as special equipment. A gear-type pump delivers transmission oil for the operation of the hydraulic system at a maximum working pressure of 2000 psi. A single hand lever controls the working position of the implement through a single-acting rockshaft cylinder. Outlets are provided for a remote cylinder and an additional hydraulic-control valve may be added. No automatic draft or depth control means is provided. An automatic safety-clutch release is built into the upper implement attachment link with the object of preventing damage to implements when striking any obstruction. This is shown in Fig. 18. The mechanism must be especially reset after each automatic disengagement. Although this mechanism disengages the clutch under conditions of overload, it cannot arrest the forward inertia of the tractor and rotating parts, which limits its effectiveness.

The Fordson Major has been carefully designed to provide a number of excellent features, including radiator shutters to control cooling-water temperatures, a recirculatory "ball-type" steering gear for easy steering, removable radiator grills, steering and parking brakes, and easy mounting of the seat. Full tracks and half tracks are available for operating conditions requiring their use. In an effort to hold operating costs to a minimum, exchange injectors with performance guaranteed equal to new are available through English Ford dealers at a price of $2.24 each. This is much nearer the price of a new spark plug than the price of a new injector and removes one of the greatest items of maintenance cost.

Marshall Sons and Company, Ltd., Gainsborough, long-time manufacturers of steam engines and other heavy equipment, manufacture the single-cylinder, two-cycle diesel tractor shown in Fig. 19. This tractor is the only one of its kind manufactured in England. Crankcase compression with reed-type air valves provides scavenging air to the cylinder. A unique air-cleaning system is provided which employs an oil-bath precleaner with an oil-soaked fiber element in the main cleaner. The crankshaft is mounted on roller bearings. Starting is effected either manually, using an ignition paper, or with an explosive cartridge. The operating weight, without solution in the rear tires, is 6,520 lb, equivalent to 163 lb per belt horsepower, which is the highest specific weight of any English tractor. Heavy three-point implement-attaching linkage is provided, with a hydraulic lift for handling the

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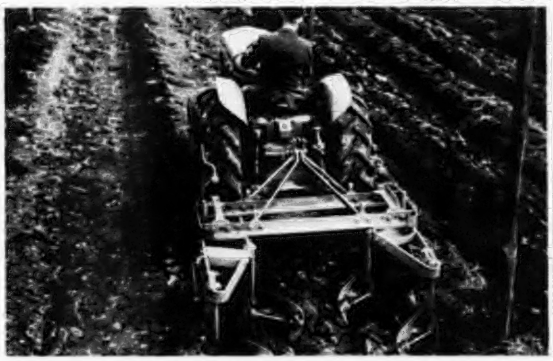


Fig. 17 Fordson Major tractor in the field

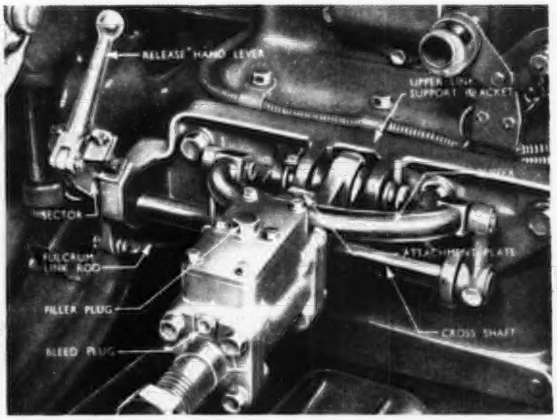


Fig. 18 Fordson Major tractor automatic overload safety release

Fig. 19 Front view of "Field Marshall" tractor

Fig. 20 Rear view of "Field Marshall" tractor showing implement attachment linkage

heavy loads, as shown in Fig. 20. No automatic control of implement draft or working depth is provided.

No description is given of the English-built Allis-Chalmers and Massey-Harris since they do not differ significantly from their American counterparts.

The tractor manufactured by International Harvester Company in Great Britain is the Farmall M type, and in general construction and appearance corresponds to the Farmall M built in the United States. It is, however, built almost exclusively with the wide-tread front axle, with provision for the use of the conventional narrow-tread double front wheel. The tractor is regularly powered with a four-cylinder diesel engine, developing 50.5 hp at the flywheel, but is optionally available with a gasoline or distillate-burning engine. Three-point implement attaching linkage is provided, which includes leveling and lateral adjustment manually operated from the driver's seat.

From a study of English tractors, a number of facts are evident, as follows:

1 They are conservative in design and appear to be well built and to have a satisfactory working life.

2 English general-purpose tractors are of the four-wheel design, with front and rear treads adjustable for width. This type is possible because many tall crops grown in the United States are not encountered in the markets served by English manufacturers. Much effort has been expended toward providing special models for requirements such as vineyards and hop fields.

3 English manufacturers have without exception made three-point implement attaching means available for their tractors. Only the Ferguson tractor provides an automatic means for controlling implement draft and working depth.

4 The engines in English wheel tractors have a stroke-to-bore ratio ranging between 1.102 and 1.43, with an average of 1.216. The six-cylinder Meadows engine, with a bore and stroke of 5.118 in, used in the recently tested Fowler "Challenger" track-type tractor, is the only short-stroke engine used on any English tractor. Its specific fuel consumption compares favorably with the best American practice. In general, the specific fuel consumption of English wheel tractors is high, which is strange in an area where fuel is artificially expensive.

5 Piston speeds range from 1068 to 1667 fpm. That of the Meadows engine is 1322 fpm at 1550 rpm. These values are conservative.

6 Although the British standard power take-off speed is 536 rpm plus or minus 10 rpm, the same as the American standard, many English wheel tractors, including those in highest production, do not provide this speed at rated engine speed.

7 Some tractors having high and low-range transmission speeds are provided with two power take-off speeds. This appears incidental rather than necessary to meet any existing implement requirement.

8 No direct engine-driven power take-off is provided on any English-built tractor.

France is today a land of strange and conflicting paradoxes. The inability to produce foodstuffs on a self-supporting basis, the tottering economy, and debased currency are interrelated evidences of national distress. Yet nowhere are "dirt farmers" more eager to accept power farming. This stems from a number of factors: the desire to replace all work animals so as to have more grain to market, the realization that better tillage and cropping practices will result in greater crop yields, the increasing acreage of rice and other cereals requiring tractor power for efficient production, and the desire for faster field and highway transportation than is possible with horses and oxen. Another significant reason for investing in farm equipment is that increasing inflation and the declining value of currency causes such investments to continually increase in value.

Fully appreciating the seriousness of the critical inability of the nation's farms to produce sufficient food to place the country on a self-supporting basis, the French Ministry of Agriculture is actively promoting a broad educational policy directed toward increasing the manufacture and use of power-farming machinery. This has as its objective improving the fertility of the soil and the resulting increase in food production. The scarcity of power machinery on French farms does not reflect either a lack of desire or inability to pay. It is more the result of confusion within the national economy which has resulted in a declining production and lack of foreign exchange which has reduced imports of farm machinery to a trickle.

The brightest and most optimistic sign of better things to come occurred in March of this year when the world's

greatest farm machinery exhibition, the Salon International de la Machine Agricole, was held in Paris. Truly international in its scope, 1321 different items of farm machinery were on display, including 130 models of wheel tractors produced by 60 different manufacturers.

As of January, 1953, the French Ministry of Agriculture announced that the number of tractors on French farms totaled 204,250, of which 176,800 are individually owned. Of these 193,350 were of the wheel type and 10,900 were of the track type (4)*. These may in turn be classified into sizes as follows:

Wheel tractors	Quantity	Percent
Less than 15 hp	26,000	13
15 to 25 hp	98,000	51
25 to 35 hp	45,000	23
Over 35 hp	24,350	13
Track-type tractors		
Less than 15 hp	1,400	13
15 to 40 hp	6,900	63
Over 40 hp	2,600	24

The average mechanized farm in France is one of 100 acres. The degree of mechanization referred to farms of the various size groups is as follows:

Size of farms	Percent mechanized	Size of farms	Percent mechanized
12-25 acres	7	50-125 acres	28
25 50 acres	12	125-250 acres	56
		Over 250 acres	77

The use of individually owned tractors with respect to the size of farms is as follows:

Size of farms	Number of tractors used	Percent of individually owned tractors
Less than 37.5 acres	25,000	14.1
37.5 to 75 acres	43,000	24.3
75 to 125 acres	40,500	22.9
125 to 250 acres	39,500	22.3
Over 250 acres	28,800	16.4

Tractors are classified as to the fuel burned as follows:

Gasoline or kerosene	142,300
Gas oil	35,450
Fuel oil	26,500

The 26,500 fuel-oil tractors are of the semidiesel or hot-bulb type, and of these, 16,700 are of French manufacture.

Some idea of the potential requirement is given by the following data as to the number and sizes of French farms:

Total number of farms	2,418,138
Average size of all farms	37.75 acres

*Numbers in parentheses refer to the appended references.

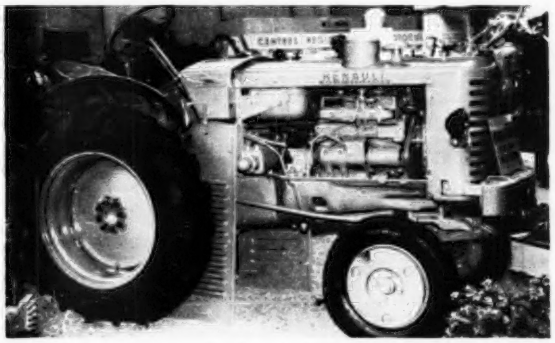


Fig. 21 Renault farm tractor

The number and size of farms are given as follows:

Size of farms	Average size in group	Number
Less than 25 acres	10.0 acres	391,599
Less than 37.5 acres	15.0 acres	1,198,624
25 to 50 acres	35.0 acres	137,948
37.5 to 75 acres	52.5 acres	334,233
50 to 125 acres	75.0 acres	91,472
75 to 125 acres	87.5 acres	161,134
125 to 250 acres	172.5 acres	78,214
Over 250 acres	480.0 acres	24,914

The overlapping of classifications results from differences in reporting census figures from the different provinces.

Of all wheel tractors on French farms at the end of 1952, 44.2 percent are French-built, 8.6 percent of German manufacture, 14 percent from the United Kingdom, 30 percent from the United States and Canada, with the remainder from Sweden, Austria, Czechoslovakia, Hungary, and other countries. The 82,000 individually owned French-built wheel tractors on farms were built by a total of 40 different manufacturers, of whom only seven have built more than 1000 tractors total, as follows:

Renault	29,600	Sift	2,000
Vierzon	12,950	Massey-Harris Pony	1,970
Latil	3,990	Le Percheron	1,800
MAP	2,660		

Because of the poor response of French manufacturers to requests for information regarding their products, the descriptions of tractors built in France are rather meager. Renault tractors are produced in the nationalized automotive works, Regie National des Usines Renault. These tractors are built in one basic model with a rating of 22 dhp and 30 bhp as shown in Fig. 21. Three power plants are available as follows:

1 The Renault light truck gasoline engine, 3.35-in bore x 4.134-in stroke, which delivers 30 belt hp. This engine is also available modified for operation on either distillate or alcohol.

2 The English Perkins four-cylinder diesel engine, 3½-in bore x 5-in stroke, operating at 1600 rpm and developing 32 belt hp.

3 The Hercules four-cylinder diesel engine, 4¼-in bore x 4½-in stroke, operating at 1800 rpm and developing 42 belt hp. This engine is built by Hispano Suisa under license of the Hercules Motor Company, Canton, Ohio.

The tractor is equipped with a belt pulley located on the right side forward of the rear axle. This pulley is mounted on a cross-shaft, the other end of which serves as a side power take-off and which runs at 625 and 556 rpm at engine speeds of 1800 and 1600 rpm. The rear power shaft is made to the 1⅜ in ASAE-SAE standard and operates at 590 and 525 rpm at the above engine speeds. On 11-28 rear tires, four forward speeds are available as follows:

	Engine type		
Speeds, mph	Gasoline and Hercules	Distillate	Perkins
First	2.32	1.75	2.00
Second	3.77	2.88	3.31
Third	5.37	4.05	4.69
Fourth	13.88	10.56	12.20

A hydraulic cylinder with a servo follow-up control operates a rockshaft with lifting levers for integral implements. No automatic control of working depth or draft is provided. A special narrow model with a minimum wheel

tread of 35.4 in is available for vineyard use. As with most French-built tractors, a pintle hook is regularly provided at the rear for trailer attachment. The inconsistency of travel and power take-off speeds evidences little concern for many factors essential to best implement operation.

The second largest producer of tractors is Society Francaise Vierzon, an old-time manufacturer of farm machinery. These tractors are built in four sizes, all having a single cylinder, "hot-head," semi-diesel, two-cycle engine with crankcase compression. The combusion-chamber design generally follows that of the German prewar Lanz, with the bottom removable for cleaning. Such engines are capable of handling a wide variety of low-grade fuels, including many grades of crude, peat, and shale oil, and low-quality distilled fuels. Such engines are started with a mixture of gasoline and fuel by "rocking" against compression. Should they start up backwards, which occurs as often as not, they are stopped and another attempt made. In cold weather, the unjacketed head of the combustion chamber is heated with a blow torch. A general view is shown in Fig. 22. Following are brief specifications of these tractors:

Rated belt horsepower	22	34	45	60
No. of cylinders	1	1	1	1
Bore and stroke, in	5.91 x 6.69	7.09 x 8.27	8.86 x 10.24	9.84 x 10.24
Compression ratio	6.1:1	6.7:1	6.6:1	6.1:1
Engine speeds, rpm	1000	800	630	—
Travel speeds, mph				
First	1.75	2.18	2.18	2.18
Second	2.50	3.00	3.00	3.00
Third	3.66	4.00	4.00	4.00
Fourth	5.45	7.00	7.00	7.00
Fifth	10.00	12.50	12.50	12.50
Reverse	—	2.75	2.75	2.75
Power shaft				
Diameter, in	1⅜	1.65	1.65	1.65
No. of splines	6	8	8	8
Speed, rpm	560	520	540	560
Tire size, in				
Front	5.00 x 15	6.00 x 19	6.50 x 20	6.50 x 20
Rear	10 x 28	12.75 x 24	12.75 x 28	12 x 38

Considering the power of their engines, the tires of these tractors appear to be inadequate. Travel speeds are consistent for the larger models. Only the power shaft of the smallest tractor is made to ASAE-SAE standards, but its speed is not standard. The power shafts of the three larger tractors are not to United States or British standards of size and speed, and all operate at different speeds without regard to the speed necessary for proper operation of the trailing implement. The U drawbar pivoted at its forward end may

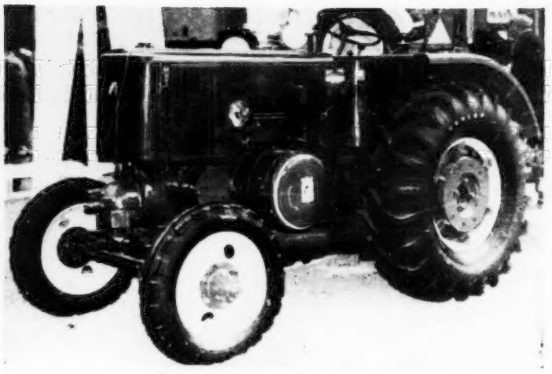


Fig. 22 Vierzon farm tractor

be adjusted vertically for use with implements of their own manufacture or trailing implements in general. No three-point implement attaching linkage is provided except for the smallest model. Treads of all four models are adjustable within relatively narrow and inconsistent ranges.

No information is available regarding the construction of the LATIL tractor except that it is a four-wheel-drive model. The MAP tractor is no longer in production. This interesting tractor was provided with a two-cylinder opposed-piston diesel engine, which had excellent torque and fuel-consumption characteristics.

The SIFT, with its name coined from the initials of its manufacturer, Societe d'Installation de Force et de Traction, of Argenteul, is built in three sizes rated at 28, 43, and 60 engine horsepower, respectively. The first is shown in Figs. 23 and 24, the second in Fig. 25. The 28-hp tractor has an interesting two-cylinder, four-cycle opposed diesel engine, one cylinder of which extends forward of the rear axle on the right side while the other cylinder extends back of the rear axle on the left side as shown in Fig. 24. Both of the other models have conventional four-cylinder diesel engines.

Travel speeds are provided as follows:

Model	TL2—28 hp	TD4—43 hp	TL4—60 hp
No. of speeds	6	5	5
Minimum speed, mph	1.125	2.31	2.09
Maximum speed, mph	11.25	13.94	14.84

Fig. 23 Sift Model 28 tractor

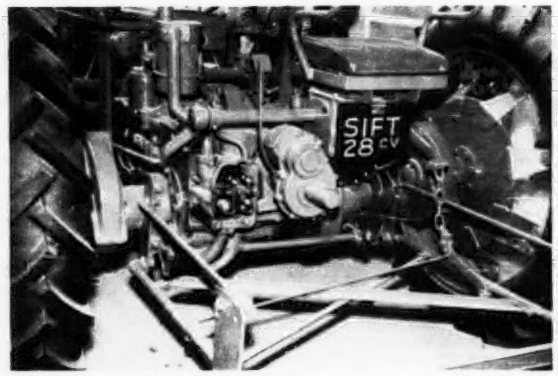


Fig. 24 Sift Model 28 tractor showing cylinder extending to rear

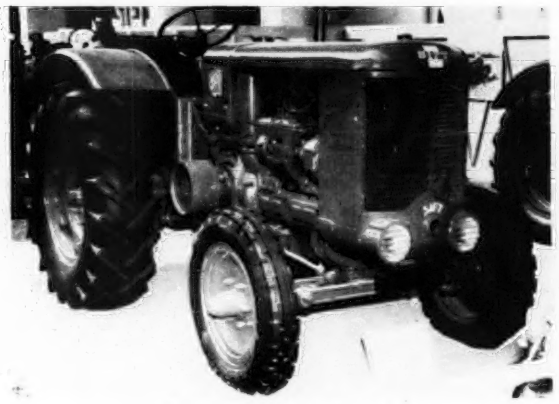


Fig. 25 Sift Model 43 tractor

LePERCHERON, built by the Compagnie General de Mechanique, is built in a single 27-hp model shown in Fig. 26. This tractor is equipped with a single-cylinder, hot-bulb, two-cycle, semidiesel horizontal engine. Bore and stroke are 6.69 in and 8.26 in, respectively, and the rated speed is 900 rpm. The engine is claimed to operate on gas oil, fuel oil, diesel fuel, and vegetable oil. Six forward speeds are provided as follows:

First speed	2.19 mph	Fourth speed	6.53 mph
Second speed	2.92 mph	Fifth speed	9.01 mph
Third speed	3.98 mph	Sixth speed	12.30 mph

Two reverse speeds of 2.5 and 9.01 mph are provided. The 1⅜-in splined power shaft operates at 555 mph. A hydraulic lift serves to raise and lower a vertically swinging U-shaped drawbar. A spring-cushion trailer pintle is also provided.

The French-built Massey-Harris PONY is generally similar to its Canadian-built counterpart, except that it is equipped with the basic SIMCA (French-built) automobile engine modified for tractor use.

The Fiat (Italian) owned SOMECA is manufactured in Saint Denis in the plant formerly manufacturing the MAP tractor. It is the only French tractor officially tested at Nebraska, which allows it to be sold in those countries which require an official test of performance as the basis for issuing an import permit. Neither France nor Italy have official

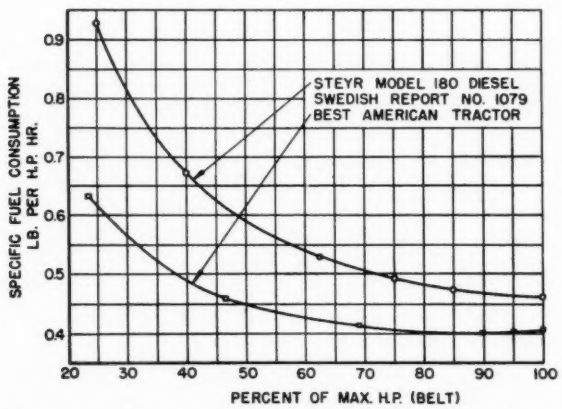


Fig. 27 Official variable-load governed-speed performance of Steyr (Austrian) tractor

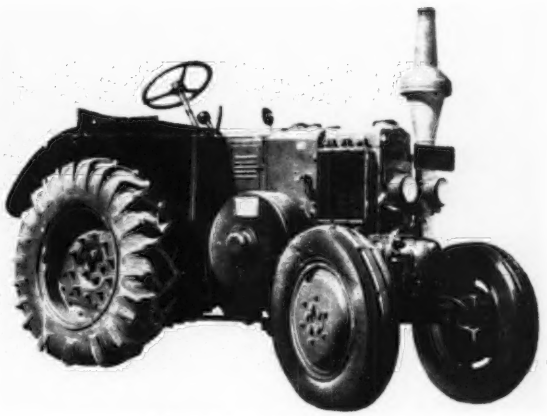


Fig. 26 LePercheron tractor

testing stations comparable with those of Nebraska, or in England, Sweden, and Western Germany.

The International Harvester Company (CIMA) has recently started production of a small tractor generally similar to the American-built Model C, except that it is equipped with the small four-cylinder diesel engine built at Neuss-am-Rhein in West Germany.

In general, French-built tractors, other than those coming from the French plants of American companies, evidently are not as suited for general farming operations as their American and English counterparts. This is probably due to the fact that limited production does not support the extensive research and development expense necessary to meet all local conditions.

With the fall of the Iron Curtain, the breaking up of the Austrian-Hungarian empire was complete. The separation of Austria and Hungary with a total of 19,000,000 acres of arable land was final and absolute. To Hungary, with its large agrarian population, went 14,500,000 acres of the best and most productive farm land in Europe. Remaining to the more urban and densely populated Austria was 4,500,000 acres of less fertile land, with which the food requirements of a hungry and war-ravaged nation must be met. In spite of tremendous difficulties, the factory of STEYR-Daimler-Puch, A. G., near Vienna brought into production three basic tractor models powered with one, two, and four-cylinder, four-cycle diesel engines with a common bore and stroke of 4.33 in by 5.512 in. These engines all operate at 1600 rpm, with a piston speed of 1470 fpm, and deliver 15, 30, and 60 bhp respectively. The two-cylinder tractor was officially tested at the Swedish State Agricultural Machinery Testing Institution operated as a part of the University of Upsala. Here it developed 25.3 bhp (84.3 percent of its rated power) with a specific fuel consumption of 0.458 lb per bhp-hr. Its specific variable-load fuel consumption is shown in Fig. 27.

A section of the single-cylinder model is shown in Fig. 28. This basic tractor is furnished in three four-wheel types, viz., regular (low-clearance), narrow-tread (vineyard), and general-purpose (high-clearance). All three have a wheelbase of approximately 65 in with adjustable treads as follows: Regular and general-purpose, 41.1 to 68.9 in; narrow, 38.0 to 53.7 in.

The larger two and four-cylinder models both have front

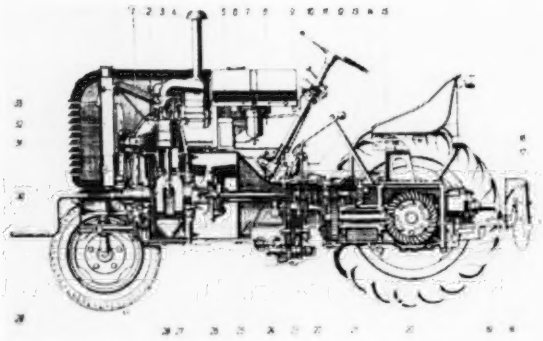


Fig. 28 Section showing single cylinder engine of the Steyr tractor

axles mounted on double transverse leaf springs. Although well adapted to road work and transport purposes, the design is poorly suited for use with any front-mounted implement, particularly with a front-mounted manure loader. All tractors are available with oil-bath air cleaners, centrifugal dry precleaners, and Austrian-built fuel injectors and pumps. The crankshafts of the single and two-cylinder engines run in roller bearings. That of the four-cylinder engine is journaled in leaded bronze split bushings. Specifications of the tractors showing significant dimensions are shown in Table 5.

Both a drawbar and a pintle trailer hitch are provided and three-point implement attachment linkage is available on the smallest model only. A moderate-pressure hydraulic-lift system (853 psi relief valve opening) is available for rockshaft operation through an angle of 80 deg. Linkage and hydraulic-control system is shown in Fig. 29. Although

TABLE 5. DIMENSIONS OF STEYR TRACTORS

Model	80	180	280
Rated belt horsepower	15	30	60
Number of cylinders	1	2	4
Rated engine speed, rpm	1600	1600	1600
Operating weight, lb			
Front	1055	1540	2530
Rear	1585	2420	4290
Total	2640	3960	6820
Weight per rated bhp, lb	176	132	114
Percent wt on front wheels	40	39	37
Wheelbase, in	64.96	65.3	65.3
Tires			
Front	4.00 x 15	5.25 x 16 or 5.50 x 16	6.50 x 20 or 7.50 x 20
Rear	8-24 or 8-36	9.00 x 24 or 11.25 x 24	15-30 or 14-34
Travel speeds, mph*			
First	1.12†	1.63	1.68†
Second	1.80	3.03	2.30†
Third	3.04	4.41	2.73
Fourth	4.53	9.00	3.85
Fifth	8.88	14.28	4.97
Sixth	—	—	8.75
Seventh	—	—	14.65
Reverse	1.80	1.63	2.18
Power shaft			
Size, in	1⅜ 6 spline	1⅜ 6 spline	1⅜ 6 spline
Rpm at rated engine speed	576	608	524
Mower drive			
Rpm at rated engine speed	1019	960	—
Min. turning radius, ft			
Without steering brakes	10.65	11.45	14.75
With steering brakes	5.0	5.73	12.15

*Speeds as shown are for minimum-size tire.
†Special low speeds optionally available.

Fig. 29 General view showing implement attaching linkage of Steyr tractor

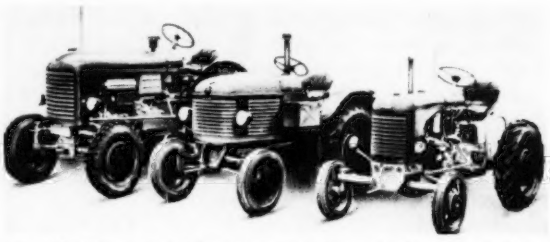


Fig. 30 Comparison of one, two, and four-cylinder models of the Steyr tractor

a power-take-off speed of 540 rpm is specified, this speed cannot be obtained at full engine speed, nor is the power take-off speed the same for all three tractors at rated engine speed. Similarly, the speed of the forward power take-off provided for mower drive is 1019 rpm on the smallest tractor and 960 rpm on the next larger size. This is higher than the usual cutter-bar speed prevailing in the United States. No appropriate speed of approximately 6 mph is available for mower operation.

Further consideration of the compromises involved in the design of these tractors reveal a number of significant factors:

1 As the result of using a common bore and stroke for the single, double, and four-cylinder models, many common parts can be used on all engines including piston rings, cylinder liners, connecting rods, bearings, and injection parts.

2 As the result of factors such as the use of a heavier flywheel on the 15-hp single-cylinder than on the 60-hp four-cylinder tractor, the weight per horsepower of the former is 176 lb as compared with 114 lb for the latter. This further results in increasing the percentage of total tractor weight carried on the front wheels and the unit pressures of the front tires against the soil. In many European soils compaction is a serious problem which is made even more serious by a compromise of this nature.

3 The high weight-to-power ratio of the single-cylinder tractor results in high costs and tends to price it beyond the ability of the small farmer to pay for it.

A wide variety of implements is available from cooperating implement manufacturers. To increase the hauling capacity of small tractors, an especially interesting two-wheel logging truck is supplied. The two wheels of this trailer

Fig. 31 Pioneer Model IFA tractor *(Automotive Industries,* October 15, 1953)

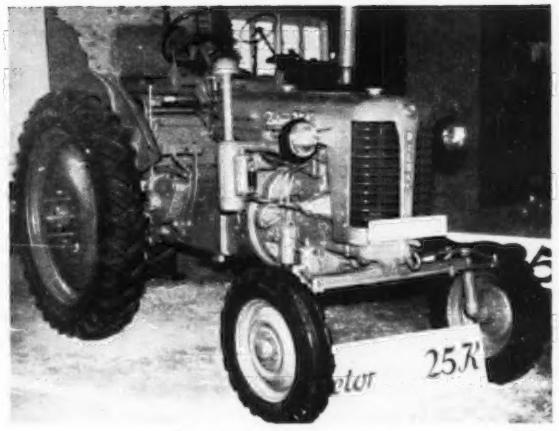


Fig. 32 Zetor farm tractor

are carried on a live axle with a differential which is powered through a suitable power shaft from the tractor power take-off. This increases the drawbar capacity of the tractor to a point far beyond the traction capacity of its own drive-wheels. The three Steyr tractors are shown in Fig. 30. The difference in appearance is probably due to the difference in the time of their appearance on the market.

In 1951, Hungary with 14,500,000 acres of arable land had a total of 18,000 tractors of all kinds on its farms or one tractor for each 805 acres. The only wheel tractor manufactured in this country is built by Hoffher-Schrantz-Clayton-Shuttleworth of Budapest, a long established manufacturer of steam engines and rasp-bar threshers. This tractor, known as the ROBUSTE, is of the single-cylinder, horizontal, two-cycle, hot-head, semidiesel type, with crankcase scavenging. Its performance record is available from Swedish test. At 730 rpm, it developed 33.4 bhp maximum at a brake mean effective pressure of 40.4 psi. The specific fuel consumption is 0.657 lb per belt horsepower, which is the highest of any diesel fuel engine so far officially recorded.

The tractor appears to follow closely the design of a prewar English Field Marshall. Although no information was available from its manufacturer, the following information was obtained from the official Swedish test report:

> The crankshaft runs on two roller bearings. An oil-bath air cleaner is regularly used. Fresh oil lubrication is provided to the main bearings, crankpins, and cylinder. The cone clutch is foot operated. Cartridge starting is available. Warming the hot spot in the cylinder head with a blow lamp as necessary for starting took a long time; the engine could usually be started after 15 to 30 min. Oil consumption was at the rate of 0.925 United States gallon per 8 hr.

Principal Dimensions

Number of cylinders	1
Bore and stroke, in	7.5 x 9.75
Engine speed, rpm	760
Piston speed, fpm	1235
Compression ratio	5.5:1
Travel speeds, mph	
First	1.92
Second	3.35
Third	4.03
Fourth	5.30
Wheelbase, in	74
Weight without driver, lb	
Front	2510
Rear	3370
Total	5880
Weight on front wheels, percent	43.7

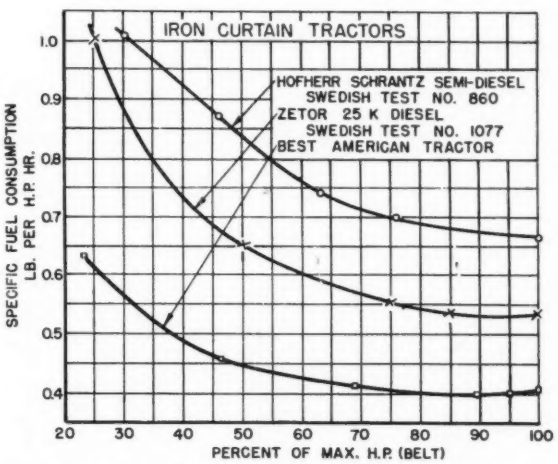


Fig. 33 Official variable-load governed-speed performance of Zetor and Hofheer-Schrantz-Clayton-Shuttleworth tractors

The Soviet Zone of Germany contains within its borders 12,500,000 acres of land generally more productive than the soil of Western Germany. As of 1951, there were a total of 12,000 tractors on farms or one tractor for each 1040 acres (1). *Automotive Industries* reports that a Pioneer Model IFA tractor, shown in Fig. 31, was exhibited at the recent Leipzig Fair. This is powered with a four-cylinder diesel engine having 310 cu in displacement and delivering 40 bhp at 2150 rpm, which is equivalent to 81.8 psi brake mean effective pressure. Starting is effected by compressed air, and five forward speeds are provided.

No information is available regarding any tractors built within the USSR.

Czechoslovakia, with 13,750,000 acres of arable farm land was reported to have a total of 29,000 tractors on farms as of January 1, 1951 (1), or one tractor for each 475 acres of land. The only wheel tractor built in the country is the ZETOR, built by Zbrojovka of Brno. Little data other than a photograph (Fig. 32) was available from its manufacturer, but it has been officially tested in Sweden so its performance is recorded. The maximum belt horsepower developed under official test conditions comparable with those at Nebraska was only 20.9 bhp, or 83.6 percent of the manufacturer's

(Continued on page 244)

Fastening Underlayment

E. George Stern

TO OBTAIN a smooth, flat base for linoleum, asphalt tile, rubber tile, wall-to-wall rug, and other finished floor covering over rough sub-flooring in both new constructions and renovations, Douglas fir plywood and hardboard are used extensively as underlayment.

When such procedure found criticism because of adverse observations, it was justified mainly because of the use of plain-shank nails or staples for fastening the underlayment. These fasteners provide little lasting holding power especially in green or partially seasoned subflooring. Even if kiln-dried prior to installation, the subflooring usually becomes wet during construction as a result of its exposure to the elements and because of moisture absorption from other building components, such as wet plaster. This moisture causes the plain-shank nail and staple to lose their original holding power to such an extent that the underlayment, no longer held rigidly, becomes springy and squeaky and its joints become uneven.

Furthermore, cyclic changes in weather and periodic heating of the building cause cyclic changes in moisture in the subflooring. Such repetitive changes cause the smooth nail to creep and its head to back out. This nail "popping" is ruinous to most floor coverings, causing unsightly bumps which later develop into mars, holes, breaks, and tears.

These aggravating defects, until recently accepted as unavoidable, have been fully eliminated by use of properly threaded underlayment nails which provide satisfactory holding power even if the flooring is subjected to continuous pounding from day to day.

On the basis of VPI Wood Research Laboratory Bulletin No. 13, at least twice the number of staples is required to provide the pull-through resistance offered by the heads of underlayment nails.

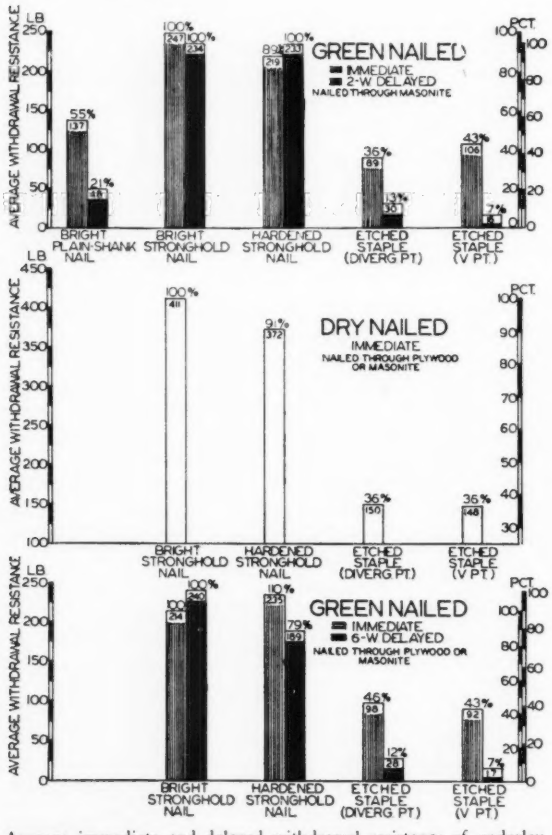
Driven into *dry* southern pine and withdrawn immediately, the average axial withdrawal resistance of etched staples with divergent or V points is 36 percent of that of the bright annularly threaded nail tested.

Driven into green pine, plain-shank nails average 55 percent if withdrawn immediately, and 21 percent, if withdrawn after 2-week delay, of the respective holding power of the threaded nail. Staples with divergent and V points, respectively, offer only 36 and 43 percent of the immediate and 13 and 7 percent of the 2-week delayed withdrawal resistance of this threaded nail; and 46 and 43 percent of the immediate and 12 and 7 percent of the 6-week delayed withdrawal resistance of the threaded nail.

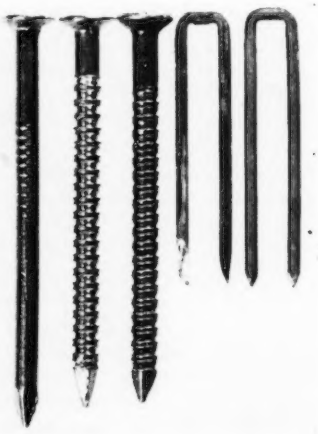
The observed pull-through resistance of the heads and the immediate withdrawal data might suggest that twice to three times the number of staples would provide the same service as properly threaded nails. However, the delayed withdrawal data indicate that neither plain-shank nail nor staple can render satisfactory service for fastening underlayment if initially driven into green or partially dry lumber or if the dry-nailed or stapled lumber has an opportunity to change its moisture content while in service. On the other hand, the holding power of a properly threaded underlayment nail is ample for permanently fastening underlayment rigidly and tightly.

This paper was prepared expressly for AGRICULTURAL ENGINEERING. It is based on development work performed jointly by the Wood Research Laboratory of Virginia Polytechnic Institute and the Independent Nail & Packing Co., Bridgewater, Mass., manufacturer of the tested nails.

The author — E. GEORGE STERN — is research professor of wood construction, Virginia Engineering Experiment Station, Virginia Polytechnic Institute.



Average immediate and delayed withdrawal resistance of underlayment nails and staples driven through ¼-in-thick plywood or masonite underlayment into dry or green southern pine



From left to right, twice actual size: 1¼ x 0.082-in bright plain-shank nail, 1¼ x 0.087-in bright and 1¼ x 0.080-in hardened annularly threaded Stronghold nails, and ⅞ x 0.050-in etched staples with divergent and V points subjected to tests on their resistance to axial pull-through and withdrawal immediately after driving and 2 or 6 weeks after seasoning of the nailed southern pine

Measuring Resistance of Potatoes to Bruising

Richard L. Witz
Member ASAE

INCREASED use of potato harvesters, mechanical potato handling and large bin storages have emphasized need for developing varieties of potatoes resistant to bruising. It has become increasingly important to be able to measure the resistance of a particular variety to bruising. Especially in developing new varieties is it advantageous to know as soon as possible which selections are bruise resistant. Present methods provide that a selection has to be increased to sizeable quantities before information on bruising can be obtained and even then such information is in the form of general impressions and not scientific data.

Equipment to measure accurately bruise-resistance would reduce time and cost in potato-breeding work. It might also measure maturity of potatoes to determine proper time for digging. Another thing that this equipment might be used for is to measure results in the use of vine killers and rotobeaters.

Equipment has been developed and is used to measure the maturity and other factors with fruit and vegetables. One of the early testing devices was devised by Morris **(6)*** in 1917 using a marble and scales to measure penetration pressure of apples. Probably the best known is the Magness tester **(5)** which was reported in 1925 primarily to measure the maturity of pears. Blake **(1)** reported in 1929 on a device for determining the texture of peach fruit. In 1941, Haler **(3)** has summarized many fruit and vegetable testers and their application. An adaptation of the Magness tester was reported by Ross **(7)** in 1949 for use with pears and other fruits. It was this Ross tester which was used as a pattern to develop our first tester to be used with potatoes. In 1951, Gaston and Levin **(2)** at Michigan State College reported on methods of measuring bruises to apples. The extent of bruise was determined by measuring the diameter of the bruise resulting from dropping apples from various heights and from the application of pressure. Other testers have been used in connection with strawberries, snap beans, asparagus, and peas.

Another source of information as a background for the development of these testers was the North Dakota Agricultural College paint laboratory. Much equipment has been developed to measure the durability of paint. None of the equipment seemed to be directly applicable to potatoes but many of the ideas were valuable toward the development of this equipment.

The bruises were divided into three types, namely, pressure, abrasion, and impact. The logical approach was to develop a tester for each of the types of bruises and then see if one or more could be eliminated or combined. The first one was built and used in 1949.

DESCRIPTION OF TESTERS

Pressure Tester. This tester was patterned after the Ross tester with only slight modification. The regulator was omitted and the electrical device did not seem necessary. After reaching the necessary pressure, the plunger punctures the potato rapidly. This fast motion of the plunger tends to stabilize the hand on the gage, making it easy to get a satisfactory reading.

The pressure tester is made from a hypodermic syringe which has a ¾-in cylinder. The diameter of the plunger is 0.155 in with a curvature over the end of the plunger of 0.25 in. By comparing the area of the plunger with that of the cylinder, air-pressure readings obtained from the gage can be converted to pounds per square inch by multiplying by 23.57.

The pressure tester is shown in Fig. 1. The flow valve (C) was used when the cylinder was tight. After considerable usage the cylinder developed some leakage which eliminated the need for this valve. This leakage also eliminated a need for an exhaust valve to release the air after the puncture which was originally used. The pressure gage should have a range of from 0 to 40 lb per sq in with divisions of one pound.

Abrasion Tester. The abrasion tester was next developed because of interest in something to measure resistance to skinning. This tester is shown in Fig. 2. After trying various types of abrasive surfaces, both flat and round, a coarse, ¾ x 3 in emery wheel seemed to work the best against the irregular surface of the potato. It can grab the skin without injuring the potato. Little difficulty has been encountered with this part of the machine except that frequent cleaning of the emery wheel is required.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Power and Machinery Division. The results reported represent the combined efforts of J. H. Schultz and Robert Johansen, horticultural department, North Dakota Agricultural College; H. Findlen and A. H. Glaves, Potato Research Center, U.S. Department of Agriculture, East Grand Forks, Minn., and John Garland and Ralph Hansen, former graduate students in agricultural engineering, North Dakota Agricultural College.

The author — RICHARD L. WITZ — is associate agricultural engineer, North Dakota Agricultural College.

*The bold-faced numbers in parentheses direct attention to the references appended to this paper.

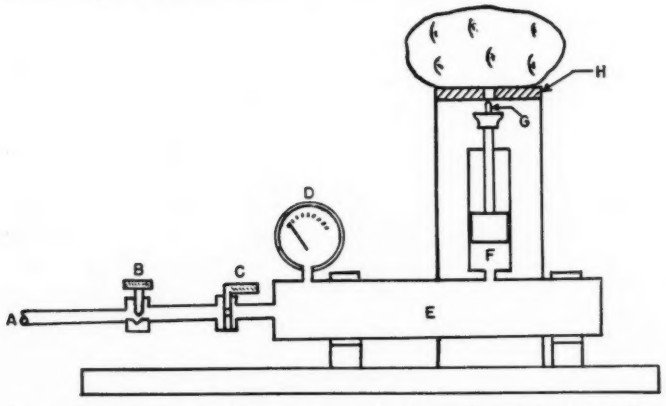


Fig. 1 Shematic drawing of pressure tester: A, air line; B, needle valve; C, flow valve; D, air gage; E, air chamber; F, cylinder; G, plunger, and H, table

A basket to hold the potato was developed, using a simple vise with prongs on the jaws. It was necessary to hold the potato against the emery wheel at a constant pressure so a cylinder ($1\frac{3}{16}$-in diameter) was used in connection with a pressure-regulating valve to maintain this constant pressure. After preliminary trials, all tests were operated at 12 lb per sq in air pressure, or a total force of 13.29 lb minus the weight of basket, piston, and potato. The basket and piston weighed about 4 lb.

The torque arm was calibrated in such a way that each division on the scale was equivalent to 2 in-lb. These readings may be converted to torque in inch-pounds by multiplying by 2, or converted to force in pounds by multiplying by $1\frac{1}{3}$.

Impact Tester. The impact tester was developed to measure, if possible, the relative amount of dropping the various varieties could withstand. This is very important when dropping potatoes into trucks and storage bins.

Several models of this machine have been built. The 1951 model lacked rigidity and readings varied considerably. A completely new machine was built in 1952. The 1952 model was used for the 1953 tests except for the use of a new dial indicator designed to withstand shock.

The potato is held in place by pushing it against a flat plate. The plate has a $\frac{7}{8}$-in hole to allow for the passage of a $\frac{3}{4}$-in ball (E). The potato is held against this plate with a basket supported by a piston with air pressure of 12 lb. The cylinder is constructed from a brass well cylinder ($1\frac{5}{8}$-in diameter). The force applied is 24.89 lb minus the weight of the basket, piston, and potato. The basket and piston weighs 1528 g.

Readings from this tester, shown in Fig. 3, measure actual penetration of the potato. The dial indicator is set

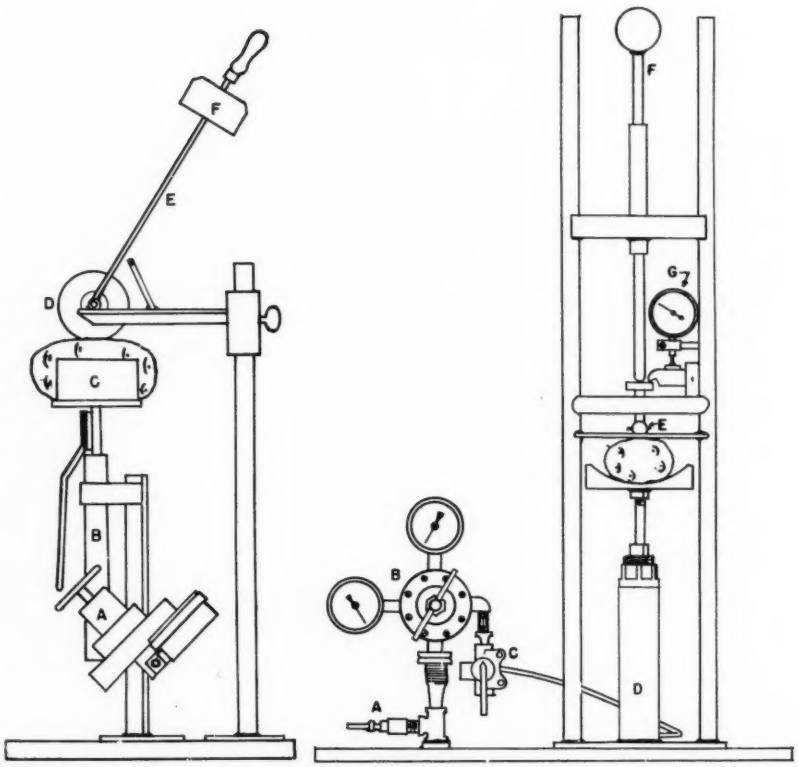


Fig. 2 *(Left)* Schematic drawing of abrasion tester: A, regulator valve; B, air cylinder; C, jaws to hold potato; D, emery wheel; E, torque arm, and F, torque-arm scale • Fig. 3 *(Right)* Schematic diagram of impact tester: A, air connection; B, pressure regulator; C, three-way valve; D, air cylinder; E, ¾-in ball; F, weight, and G, dial indicator

TABLE 1. RANKING OF POTATOES BY THE VARIOUS TESTS FOR 1949, 1950, 1951, and 1953

Pressure Bruising

Rank*	1949	1950	1951	1953
1	Pontiac	Pontiac	Pontiac	Pontiac**
2	Triumph	Triumph	Triumph	Triumph
3	Cobbler	Cobbler	Cobbler	Cobbler

Abrasion Bruising

Rank*	1950	1951	1953
1	Pontiac	Cobbler	Cobbler
2	Cobbler	Pontiac	Pontiac**
3	Triumph	Triumph	Triumph

Impact Bruising

Rank*	1951	1953
1	Cobbler	Pontiac**
2	Pontiac	Cobbler
3	Triumph	Triumph

*Potatoes are ranked from most resistant to least resistant.
** Pontiac potatoes used in the 1953 tests were Red Pontiacs.

TABLE 2. SUMMARY OF THE ANALYSIS OF STATEWIDE VARIETY TRIAL, 1953

	Specific gravity	Pressure tests	Abrasion tests	Impact tests
Varieties (15)	**	**	**	**
Locations (4)	**	**	**	**
Replications (2)	ins	ins	ins	ins
Variety x location interaction	ins	**	**	**
Mean	1.083	24.29	5.91	15.05
Standard deviation	0.0052	5.06	1.33	3.96
Coefficient of variation, %	0.48	8.5	29.8	26.3
LSD* variety means	0.0027	0.452	0.291	0.87
LSD location means	0.0052	0.224	0.15	0.45
LSD individual sample means	0.0010	0.876	0.58	1.73

**Highly significant
*LSD - least significant difference at 5 per cent level
ins - insignificant

TABLE 3. PRESSURE TESTS FROM THE STATEWIDE VARIETY TRIALS, 1953

Location	Pressure Units*				
	19.50-22.49	22.50-25.49	25.50-28.49	28.50-31.49	31.50-34.49
	Variety	Variety	Variety	Variety	Variety
Grand Forks	92.49-2R	Cobbler Early Gem Triumph 2124-10R 2200-1R	Manota 457-1 2098-1 2104-3R 2188-2R 2470-3 W-1301	Redkote Red Pontiac	
Langdon	Cobbler Early Gem 92.49-2R	Manota Triumph 2124-10R W-1301	Red Pontiac 457-1 2098-1 2104-3R 2188-2R 2200-1R 2470-3		Redkote
Williston Dry Land	Cobbler Early Gem Manota Triumph 2124-10R 92.49-2R	Red Pontiac 2098-1 2104-2R 2188-2R 2200-1R 2470-3 W-1301	Redkote 457-1		
Williston Irrigation	Cobbler Early Gem Triumph 2124-10R 92.49-2R	Manota Red Pontiac 457-1 2098-1 2104-3R 2188-2R 2200-1R W-1301	Redkote 2470-3		

* Pressure units times 23.565 equals pounds per square inch.

TABLE 4. ABRASION TESTS FROM THE STATEWIDE VARIETY TRIALS, 1953

Location	Abrasion Units*				
	5.00-5.49	5.50-5.99	6.00-6.49	6.50-6.99	7.00-7.40
	Variety	Variety	Variety	Variety	Variety
Grand Forks	Manota 2098-1 2188-2R W-1301	Early Gem Redkote Red Pontiac Triumph 457-1 2200-1R 92.49-2R	Cobbler 2104-3R 2124-10R		2470-3
Langdon	Manota Red Pontiac Triumph 2124-10R 2200-1R	Cobbler Redkote 457-1 2098-1 2104-3R 2188-2R 2470-3 92.49-2R W-1301	Early Gem		
Williston Dry Land		Manota Redkote Red Pontiac Triumph 457-1 2104-3R 2124-10R	2188-2R 2470-3 W-1301	Cobbler Early Gem 2098-1 2200-1R 92.49-2R	
Williston Irrigation		Manota Triumph 457-1 2098-1 2124-10R 2470-3	Cobbler Redkote Red Pontiac 2188-2R 2200-1R 92.49-2R W-1301	Early Gem 2104-3R	

* Abrasion units times 2.0 equals inch-pounds of torque.

on zero for each reading, but the indicator operates on a lever arm so that direct readings are not obtained. The latest model (1953) gave readings which, if multiplied by 0.002374, the actual penetration in inches would be obtained. The weight which is dropped consisted of a 1⅜-in steel ball welded to a ⅜-in rod and weighing 374.2 g. The semistationary weight, which includes a ¾-in ball, a cotter key, a short ⅜-in rod and a gage ring, weighs 94.4 g.

Since this tester reads penetration, it means that a low number indicates a tough potato and a high number indicates a softer potato. This is reverse from the other readings and should be kept in mind.

USE OF THE EQUIPMENT

All machines have given highly significant results when testing various varieties of potatoes. Varieties have consistently remained in the same order over a period of years as shown in Table 1.

North Dakota Statewide Variety Trial. The North Dakota statewide variety trial is conducted every year by the North Dakota Agricultural Experiment Station to compare some of the new unnamed varieties with varieties commercially grown in the state. Yield tests and other data are obtained by the horticultural department of the College. In the 1953 trials the varieties were grown at four locations in the state. From each of the 15 varieties at the four locations 20 potato samples were obtained from two of the four replications grown. A summary of the results is shown in Table 2 and the more specific results in Tables 3, 4, and 5. The latter three tables are designed to show the effect of the interaction between variety and locations as well as to indicate the general resistance of the various varieties to bruising.

The variety-location interaction is highly significant as it indicates that varieties react differently with a change in locations. Table 2 also gives the coefficient of variation which is lowest, 8.5 per cent, for the pressure tests and high for the other two tests, 29.8 per cent for the abrasion and 26.3 per cent for the impact tester. It is hoped that improvement in design may reduce this within-sample

TABLE 5. IMPACT TESTS FROM THE STATEWIDE VARIETY TRIALS, 1953

Location	Impact Units*			
	11.50-13.49	13.50-15.49	15.50-17.49	17.50-19.49
	Variety	Variety	Variety	Variety
Grand Forks	Early Gem Manota Redkote 457-1 2098-1 2104-3R 2188-2R 2200-1R 2470-3 92.49-2R	Cobbler Red Pontiac W-1301	Triumph 2124-10R	
Langdon	Redkote 457-1 2188-2R 2200-1R	Early Gem Manota Red Pontiac 2098-3R 2104-3R 2470-3 92.49-2R	Triumph W-1301	Cobbler 2124-10R
Williston Dry Land		Manota Red Pontiac 457-1 2200-1R 2470-3	Cobbler Redkote Triumph 2124-10R 2188-2R 2098-1 W-1301	Early Gem 2104-3R 92.49-2R
Williston Irrigation	2188-2R	Cobbler Manota 457-1 2098-1 2104-3R 2124-10R W-1301	Redkote Red Pontiac 2200-1R 2470-3	Early Gem Triumph 92.49-2R

* Impact units times 0.002374 equals penetration in inches.

TABLE 6. EFFECT OF VINE TREATMENT ON THE SKINNING TESTS

Variety, Triumph

Average of 20 tubers, 2 tests per tuber

Vine treatment	Date Tested			
	Sep. 22	Sep. 29	Oct. 7*	Oct. 17
Heavy Burn - Aug. 30	5.26	5.58	5.27	6.87**
Rotobeat "	5.33	5.80	4.93	6.80
No treatment	3.95	4.51	4.37	5.24
Sig. diff. (5 percent)	0.31	0.38	0.32	0.44
Heavy Burn - Sep. 23		4.57	4.32	5.67
Light Burn "		4.32	4.05	5.37
Rotobeat "		4.17	3.98	5.57
No treatment		3.90	3.65	4.93
Sig. diff. (5 percent)		0.30	0.32	0.34

* Soil very wet which may account for lower readings.

** A similar sample was soaked in water for 1½ hr, the average reading being 6.24.

variation of the abrasion and impact testers.

Vine-Killing Experiments. During the 1950, 1951, and 1952 seasons the equipment was used to measure results of a vine-killing experiment in cooperation with the USDA potato research center at East Grand Forks. Practically no significant differences were obtained during the 1951 and 1952 seasons although samples were set up on a five-replication basis. The reason for lack of differences was probably due to early maturity of all samples. The early maturity was due to early blight during 1951 and to weather conditions in 1952. The failure to measure differences was probably due to lack of difference in the samples.

The skinning tests in 1950 are shown in Table 6. Significant differences are shown in most tests between the treatment and check plots. Readings became progressively higher as the time after treatment was increased except for the October 7 readings. These readings were made immediately after digging and digging followed a heavy rain. This indicated that readings should not be made immediately after digging when the effect of soil moisture is still a factor. On all future tests the samples were stored at a temperature of 70 F for at least 24 hours before making tests.

CORRELATION BETWEEN TESTS

Continual checks have been made to determine if any correlation exists between the three tests, or between any of the tests and specific gravity. No correlation was found until the 1953 season when a rather high correlation ($r = 0.66$ with 14 deg of freedom) was found between the impact and pressure testers. This probably should not be considered too seriously because a test in 1952 with 44 deg of freedom showed only a correlation of 0.058 which was far from being significant.

Although it was hoped that one or more of the testers might be eliminated, results indicate all should be maintained and further information obtained.

All of the new selections at the North Dakota Agricultural Experiment Station were tested this year. A total of 356 samples of 20 tubers each were tested on the three testers during the 1953 season. The best procedure was to use three men, one on each tester, but operate only two testers at one time with the third man keeping data. It was impossible for one person to take data from three people at one time. The time required to obtain data on all three tests, using the above procedure, approximated four minutes per 20-tuber sample.

REFERENCES

1 Blake, M. A. A device for determining the texture of peach fruits for shipping and marketing. New Jersey Agricultural Experiment Station Circular 212, February, 1929.

2 Gaston, H. P. and Levin, J. H. How to reduce apple bruising. Michigan State College Special Bulletin 374, September, 1951.

3 Haller, M. H. Fruit pressure testers and their applications. USDA Circular No. 627, November, 1941.

4 Hansen, Ralph W. The development and testing of equipment to measure the resistance of potatoes to bruising and injury. Master's thesis, North Dakota Agricultural College, June, 1952.

5 Magness, J. R. and Taylor, George F. An improved type of pressure tester for the determination of fruit maturity. USDA Circular 350, 1925.

6 Morris, O. M. Studies in apple storage. Washington Agricultural Experiment Station Bulletin 266, 1925.

7 Ross, Edward. A quantitative hardness tester for food products. *Science* 109 : 204, February 25, 1949.

British and European Tractors

(Continued from page 239)

rating. Its specific variable-load fuel consumption is shown in Fig. 33, together with that of the other "Iron Curtain" tractor, the Hofherr-Schrantz-Clayton-Shuttleworth. A 1⅜-in. 6-spline, power-take-off shaft is provided. General specifications of the Zetor tractor are as follows:

Number of cylinders	2
Bore and stroke, in	4.14 x 4.72
Rated belt horsepower	25.00
Official test maximum horsepower	20.90
Specific fuel consumption, lb per hp-hr	0 532
Combustion chamber	.swirl chamber
Bmep at max. bhp, psi	81.6
Compression ratio	18:1
Rated speed, rpm	1600
Travel speeds, mph	
First	2.36
Second	3.04
Third	3.98
Fourth	6.58
Fifth	8.64
Sixth	11.11
Reverse, low	1.61
Reverse, high	4.53
Wheelbase, in	74.8
Weight, lb	
On front wheels	1510
On rear wheels	3310
Total	4820
Weight on front wheels, percent of total	31.3
Weight per belt horsepower, lb	231

The tractor was observed at the Paris Salon and was of clean design. The design of the engine appeared to follow the best contemporary German practice, as the design was completed previous to the Communist coup. Ground clearance is excellent, although some sacrifice in stability appears to have been made. The seat was well cushioned, although the upholstery was of poor quality. An oil-bath air cleaner and centrifugal precleaner are used. A three-point implement attachment system is provided, together with a hydraulic-control system operating through a rockshaft. No means of automatically controlling implement depth or draft is provided. The upper implement attaching link includes a hydraulic overload release, which operates to disengage the tractor clutch when a draft overload occurs. The construction of the device appears generally similar to that used on the Fordson Major.

REFERENCES

1 The European Tractor Industry in the Setting of the World Markets, United Nations Economic Commission for Europe, E/ECE/139-E/ECE/IM/57.

2 *Farm Implement News,* 1953 Statistical Issue.

3 *Automobile Engineer,* November, 1951.

4 Etudes du Service de la Documentation sur le Mechanisme Agricole, Directior Générale du Genie Rural et de l'Hydraulique Agricole Etude Nos. 100, 102, and 103).

5 Die Schlepperendustrie im Jahre 1952, von Friedrich Keihn, Landtechnik, Heft 5, Jahrgang 8.

6 Automobiletechnische Zeitschrift, 55 Jahrgang, Heft 5, 1953.

(To be continued in the May and June issues)

Design of Thermal Destruction Apparatus

I. J. Pflug and W. B. Esselen
Member ASAE

SEVERAL methods have been described and employed to determine the heat resistance of bacterial spores. These methods include: *(a)* the thermal death time tube method (2)*, *(b)* the thermal death time can method (1), *(c)* the rate of destruction method (9), *(d)* the thermoresistometer method (8), and *(e)* the miniature retort method (7). The thermoresistometer and miniature retort methods have been designed to increase the accuracy of studies of the resistance of bacterial spores in the temperature range of 250 to 270 F.

In the course of investigations at this laboratory the need and desirability of an apparatus such as described by Stumbo (8) became apparent. A survey of the problem indicated that the new apparatus should permit studies at temperatures as high as 300 F and at times as short as 0.0075 min. Stumbo (8) used open metal cups as containers for the samples under study. In this method of exposure the top surface of the sample and the bottom surface of the cup are in contact with the heating medium, which is saturated steam. Pflug (4) demonstrated that by sufficient reduction in the depth of a uniform layer of sample in an open metal cup the heating and cooling lag factors may be reduced to a point where they are not significant.

The basic requirement of the apparatus was that it be able to move six open metal cups rapidly into and out of a chamber that contained steam under a maximum pressure of 67.01 psia, corresponding to 300 F. Secondary considerations were *(a)* that the temperature control should be accurate and automatic, *(b)* that the timing and movement of all parts that may influence reproducibility should be done mechanically to eliminate any human error or variation, and *(c)* that it must be possible to control, vary, and measure the length of exposure. The design used in the final construction was essentially that presented by Pflug (3). Samples to be tested would be placed in small open metal cups, 0.433 in outside diameter by 0.333 in deep, punched out of 0.008-in-thick tinplate. Horizontal pistons with special compartments for the cups would convey them into the steam chamber for exposure. The cups would then be withdrawn and recovered for final testing. The piston would move in a cylinder, and compression rings would effect a seal. A pneumatic cylinder would operate the six pistons which move the cup from the loading position into the exposure position and, after exposure, return the cup and sample to the initial point for unloading into subculture or recovery tubes of media. The pneumatic cylinder would be controlled through a four-way solenoid valve which is in turn controlled by automatic timers. The temperature in the steam chamber would be controlled indirectly by a pressure controller maintaining a constant steam pressure. A vertical cross section of the machine is illustrated in Fig. 1.

CONSTRUCTION

The steam chamber consisted of a 36-in length of standard 8-in pipe with the ends closed by flanges. Its volume of approximately one cubic foot was considered the minimum for obtaining the desired temperature control. A slot was cut in the front of the pipe and a 2½ x 1¼ x 12½-in cold-rolled steel bar welded in the opening. This reinforcing bar serves as a mounting bracket for the antechamber and also to reinforce the pipe where the section is reduced for inserting the cylinders. Diametrically opposite the reinforcing bar a hole was bored in the pipe, and a 2½-in-diameter by 3-in long steel bar was welded in place for the pneumatic cylinder-rod stuffing box. The stuffing box was bored in place to obtain true alignment with the cylinders. The antechamber was made from a solid 3¼ x 4½-in steel billet. The sample-carrying pistons were 1 in in diameter, and the cylinder sleeves in which the pistons moved were 1¼ in outside diameter. Both the piston and the cylinder sleeves were made from bearing bronze. The cylinder sleeves were mounted in the antechamber and extended 4 in into the exposure chamber; the outside end of the cylinders was

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The authors—I. J. PFLUG and W. B. ESSELEN—are, respectively, associate professor and professor in the Massachusetts Agricultural Experiment Station.

*Number in parentheses refer to the appended references.

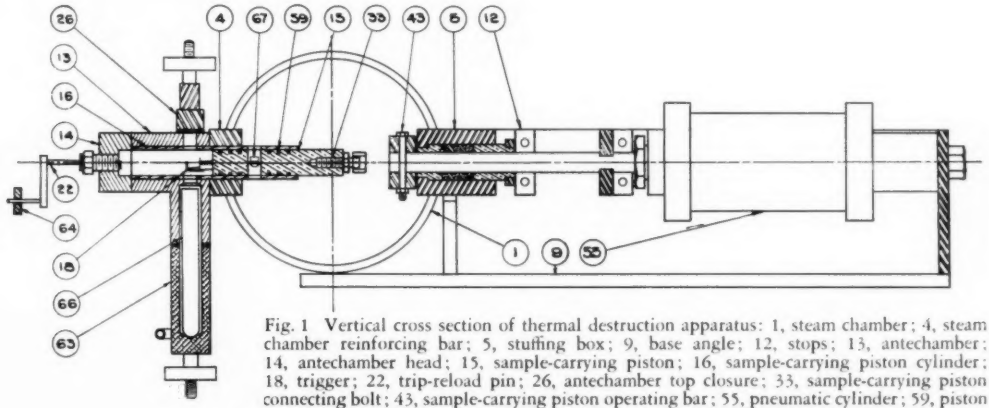

Fig. 1 Vertical cross section of thermal destruction apparatus: 1, steam chamber; 4, steam chamber reinforcing bar; 5, stuffing box; 9, base angle; 12, stops; 13, antechamber; 14, antechamber head; 15, sample-carrying piston; 16, sample-carrying piston cylinder; 18, trigger; 22, trip-reload pin; 26, antechamber top closure; 33, sample-carrying piston connecting bolt; 43, sample-carrying piston operating bar; 55, pneumatic cylinder; 59, piston rings; 63, subculture tube holder; 64, load trip bar; 66, subculture tube; 67, sample cup

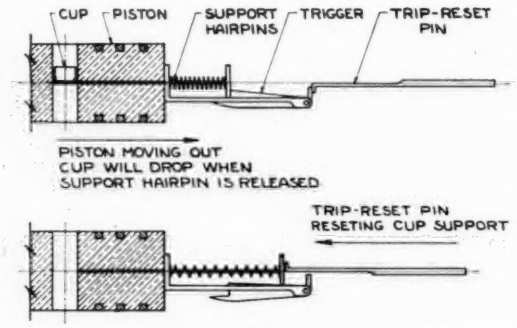

Fig. 2 Operation of trip and reset mechanism

closed by a bar acting as a cylinder head. The cylinder head and antechamber were fastened to the exposure chamber reinforcing bar with capscrews.

The sample-carrying pistons are operated by the pneumatic cylinder, which is in line on the opposite side of the steam chambers. Three compression rings are located on each side of the sample port. The position of the rings and of the relative ports are designed so that two rings carry the steam pressure at all times. The six pistons are connected to a common operating bar, which is actuated by the pneumatic cylinder. This arrangement required only one stuffing box but presented an alignment problem. To eliminate the necessity for perfect alignment, a special connecting unit was designed to transmit tensile and compressive forces and at the same time to permit a small amount of angular movement.

The sample-cup-support hairpins plus the springs and trigger mechanism are of prime importance in this design. The method of resetting and tripping the hairpins is shown in Fig. 2. It was desirable that the samples be automatically dropped into the subculture or recovery tubes upon withdrawal from the steam chamber. To accomplish this end, the trip-reset-pin unit was made adjustable; it is screwed in and locked so that the tip of the trip-pin will just meet the trigger when the pistons are withdrawn. The trip-reset pin cannot be turned from reset to trip position except when the samples are in the steam chamber. The trip-reset pin can be turned from trip to reset position when the pistons are in the load position.

The loading and unloading chamber was made pressuretight by means of the top closure bar and recovery tube support, both illustrated in Fig. 1. A pressuretight chamber is necessary for sterilization when working with microorganisms and so that compressed air can surround the samples to prevent ebullition when they are withdrawn. The apparatus was equipped with a glass wool bacteriological air filter and piping necessary to conduct the sterile air into the recovery-tube support block. A steam line was run from the steam main to the antechamber; to sterilize the apparatus, the inlet port

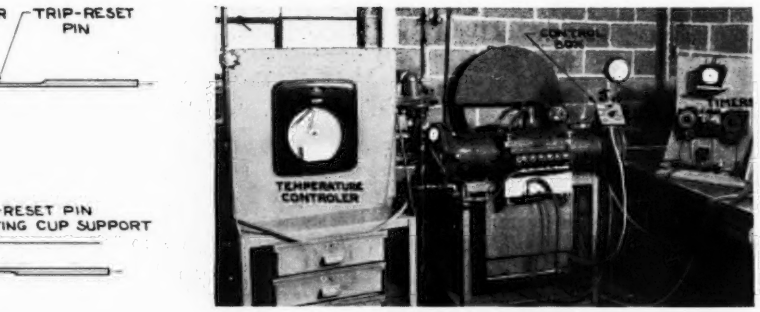

Fig. 3 Operating arrangement of the thermal destruction apparatus

of the air filter and the line to the steam main were opened. Steam then flowed into the antechamber and out through the air filter. When steam flowed freely through the system, the air filter valve was partially closed to give a steam pressure corresponding to 300 F for five minutes to effect complete sterilization.

OPERATION AND CONTROL

The temperature-control system consists of a Foxboro† Model 40 air-operated proportional-type controller having reset rate action (Fig. 3) used in conjunction with a ⅜-in air-operated needle valve. The controller maintains a constant steam pressure corresponding to the saturation pressure of the desired temperature. The steam pressure is indicated by a pressure gage. The temperature is checked, using a mercury-in-glass thermometer, smallest division 0.25 F., inserted in a 6-in-deep copper well. When the controller is properly adjusted, the temperature is maintained to within plus or minus 0.10 F.

Since this apparatus is designed to measure the time-temperature effect of different products, it is important to control and measure the time the samples are exposed to the respective temperatures. The control box in Fig. 3 is used to operate the apparatus. It contains the switches and push button illustrated in the simplified wiring diagram (Fig. 4). The control system was designed so that either an automatically timed operation or a manual operation could be employed. For simplicity, only one cycle timer‡ is illustrated in

†Manufactured by the Foxboro Co., Foxboro, Mass.
‡Manufactured by Eagle Signal Corp., Moline, Ill.

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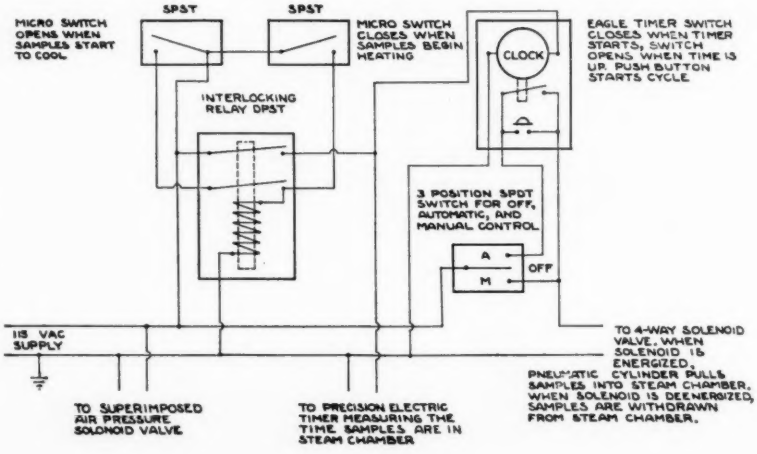
SPST
SPST
MICRO SWITCH OPENS WHEN SAMPLES START TO COOL
MICRO SWITCH CLOSES WHEN SAMPLES BEGIN HEATING
EAGLE TIMER SWITCH CLOSES WHEN TIMER STARTS, SWITCH OPENS WHEN TIME IS UP. PUSH BUTTON STARTS CYCLE
CLOCK
INTERLOCKING RELAY DPST
3 POSITION SPDT SWITCH FOR OFF, AUTOMATIC, AND MANUAL CONTROL
A
M
OFF
115 VAC SUPPLY
TO 4-WAY SOLENOID VALVE. WHEN SOLENOID IS ENERGIZED, PNEUMATIC CYLINDER PULLS SAMPLES INTO STEAM CHAMBER. WHEN SOLENOID IS DEENERGIZED, SAMPLES ARE WITHDRAWN FROM STEAM CHAMBER.
TO SUPERIMPOSED AIR PRESSURE SOLENOID VALVE
TO PRECISION ELECTRIC TIMER MEASURING THE TIME SAMPLES ARE IN STEAM CHAMBER

Fig. 4 Wiring diagram of electrical control system

Equipment for Bulk Cooling of Milk

C. N. Turner, P. E. Steiger, R. P. March and L. F. Charity
Member ASAE Assoc. Member ASAE

A METHOD of cooling, storing and handling milk in bulk on farms has been used in California since about 1938. The method is one of cooling, storing and handling milk in a refrigerated tank from which it is pumped into a pickup tank truck and delivered to a processing plant or receiving station. About six years ago this method was started in the east, near Hartford, Conn. In New York state, the acceptance of bulk milk cooling equipment increased from 40 installations in 1952 to about 250 in 1953. This rapid increase appears to be a result of one or more of the following advantages to the farmer over the can-handling method:

- A receipt for the sale of milk at the time of pickup, resulting in fewer disputes as to amount and quality of milk received by the buyer
- Fluid milk hauling costs should be lower resulting in a higher net return for milk at the farm
- Eliminating cost of cans
- A higher butterfat test and quality when handled in bulk
- A saving in the amount of milk wasted
- Elimination of labor of handling full and empty cans.
- A future hope of combining a pipe-line milking installation with the bulk tank system to eliminate all manual handling of milk on the farm.

The dairyman has shown a keen interest in the above advantages to the extent of investing $1200 to $3500 in new equipment for this method.

Field and laboratory studies of the installation and performance of bulk milk cooling equipment was started early in 1953 by members of the departments of agricultural engineering and dairy industry at Cornell University, with the New York Farm Electrification Council cooperating.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Rural Electric Division.

The authors—C. N. TURNER, P. E. STEIGER, R. P. MARCH and L. F. CHARITY—are, respectively, professor of agricultural engineering, undergraduate in agricultural engineering, assistant professor of dairy husbandry, and assistant in agricultural engineering, Cornell University.

TYPES OF COOLING SYSTEMS

Of the nine installations where detail studies were made on farms, eight were of the direct-expansion type and only one of the ice-bank type, although one other ice-bank system and two direct-expansion systems were included in studies of condensing-unit characteristics and energy consumption. The direct-expansion systems, where the freon refrigerant is in direct contact with the milk tank liner, were of both the dry and flooded evaporator types. The ice-bank systems used the dry-type evaporator located in the ice and chilled-water chamber under the milk tank liner. The chilled water was sprayed down the walls of the tank and circulated over the ice bank.

The "shock-cooling" type system, where the milk flows over a refrigerated surface and is cooled close to the desired temperature before it reaches the holding chamber, was observed in the laboratory but not studied in actual operation on the farms.

CONDENSING UNITS

The electric motor horsepower of condensing units used for direct-expansion systems with air-cooled condensers ranged from one horsepower for each 50 gal of tank capacity per milking to one horsepower for each 80 gal. Fortunately those tanks with the latter capacity were not fully loaded or cooling would have been too slow. The studies showed the ratio of one horsepower of condensing-unit capacity for each 50 gal per milking is close to the limit and may not quite meet the cooling requirements when the equipment becomes older. Water-cooled condensing units had greater cooling capacity for each horsepower than air-cooled units. It must be realized that with the direct-expansion system the capacity of the condensing unit *directly* affects the cooling rate; therefore, these systems cooled the milk slower in summer than in winter.

Fig. 1

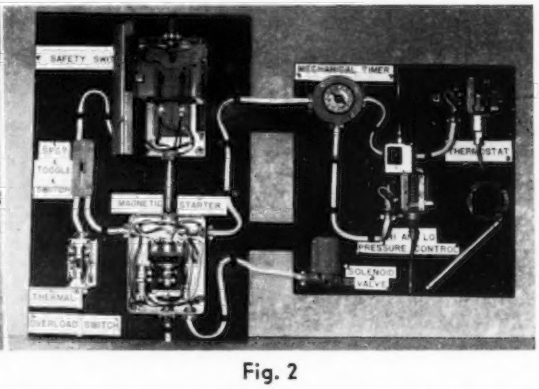

Fig. 2

Fig. 1 *(Left)* Inadequate protection and control. A burned-out 30-amp fused safety switch used to disconnect and protect a 3-hp compressor motor for a bulk milk cooler. Inadequate protection is now provided by means of a 30-amp fuse in a pigtail socket. • Fig. 2 *(Right)* Adequate protection and control. The controls on the left panel provide a master disconnecting means, thermal overload protection, interlocking protection for all motors and manual or automatic operation of the agitator. The controls on the right panel provide automatic operation of the condensing unit

The electric motor horsepower of condensing units used for the ice-bank systems was about ⅓ hp for each 50 gal of milk cooled per milking. With this system, the capacity of the condensing unit *does not directly* affect the cooling rate but rather the operating time required to build the ice bank. The rate of cooling the milk remained the same with this system summer and winter. All the many factors that contribute to the relative efficiencies of condensing units, such as ventilation and air temperatures for air cooling, water conditions for water cooling, etc., do not directly affect the performance of the ice-bank system as related to the

rate of cooling the milk to meet health or milk company requirements.

Emergency Operation

For emergency operation such as during a power failure, an auxiliary power source may be needed to cool the milk. A standby electric generator should have about 2 kw of capacity for each one horsepower of compressor-motor size. For cooling with the ice-bank system, a standby generator can be about one-third the size of that required for the direct-expansion system. Generators normally purchased for stand-by electric service on dairy farms will be adequate for operation of the small motors on ice-bank bulk coolers. The milk from one milking period can be cooled with the stored refrigeration in the ice bank; therefore, only the small motors on the circulating pump and agitator need be operated by the emergency generator during the cooling period. It has been suggested that cracked ice or spring water might save a loss of milk with the ice-bank system in the event of an emergency power failure.

Condensers

The condensers were of the air-cooled, water-cooled, and combination air-and-water-cooled types. When air cooling was used, ventilation of the condenser sometimes became a problem. In general, air cooling was used on the smaller condensing units; however, in one installation a 5-hp unit was air cooled. When water cooling was used, an adequate supply of water and good drainage sometimes became a problem. The hardness and corrosive characteristics of the water were other important considerations. Water cooling of the condensers, either in total or in part, requires special attention from the standpoint of freezing during the winter months in northern dairy states.

Condensing units were either located inside or outside the milkhouse. While the outside location might appear to be more efficient and result in a neater milkroom appearance, the inside location with proper provision for outside air supply appears to be most satisfactory. The condensing unit, if located outside, may not operate satisfactorily during very cold weather; under these conditions, starting condenser pressures may be too low to force sufficient refrigerant to the evaporator. Oil separators also may fail to function properly returning liquid refrigerant with the oil to the compressor.

The condensing units on the ice-bank coolers were located in the milkhouse and operated over a long period of time. This provided an opportunity to utilize the heat from the condenser to warm the milkhouse, especially important at night. It supplemented other sources of heat to keep the milkhouse dry and to keep water from freezing in the pipes. On the other hand, the direct-expansion coolers with the condensing unit located inside produced considerably larger quantities of heat over a short period of time when the operator was most likely to be in the milkhouse, an advantage in the cold months but a possible disadvantage in summer.

Evaporators

The area of the milk-tank liner in contact with the refrigerating medium varied considerably. In the direct-expansion type, the evaporator was usually in contact with a major portion of the bottom of the tank liner resulting in a large cooling area in contact with the milk. In the ice-bank system the refrigerating medium (chilled water) was in contact with a considerably larger area of the tank liner. This appeared to be particularly effective in keeping the blend temperatures low during the second or subsequent milkings.

Wiring and Control Panels

The electric wiring and control equipment appeared to be the most varied and the weakest part of the bulk milk cooling installations. Both the manufacturers of the equipment and the agencies installing it appear to have given little attention to this phase of bulk cooling. Not one installation has been found that incorporates all the desirable features of an adequate, safe and flexible electrical control system.

FIELD STUDIES OF PERFORMANCE

Records on nine farm bulk cooling tanks were obtained by the use of temperature recorders and graphic wattmeters to correlate energy consumption, condensing-unit operating periods, temperatures of the milk, inside and outside temperatures of the milkhouse, air temperatures entering and leaving the condensers, and the weight of milk cooled. Data were obtained for weekly periods on each farm during February and March and again during July and August.

The direct-expansion systems showed a low electric energy consumption, averaging 0.9 kw-hr for each 100 lb of milk cooled. The ice-bank systems used 1.6 kw-hr to cool 100 lb of milk. The consumption was usually lower with both systems when water-cooled condensers were used although the small condensing units seldom need water cooling.

The direct-expansion system, with the relatively large compressor motor, required additional expense for electric service including larger wires and switches. Large motors

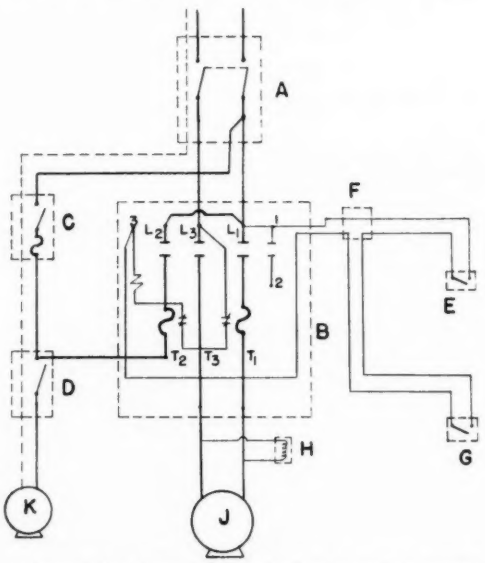

Fig. 3 Controls for direct-expansion bulk-milk cooling system with direct thermostatic control (3-wire, 115/230 v). A, 3-pole SN safety switch; B, 3-pole 230-v magnetic starter; C, SPST thermal overload switch or safety switch with time-delay fuse normally open or "off" (a mechanical timer may be added to reduce the possibility of churning); D, SPST toggle switch normally closed or "on"; E, thermostat with start button or thermostat and mechanical timer; F, junction box; G, combination high- and low-pressure control; H, 230-v liquid line solenoid valve (on dry-type evaporators only); J, 230-v compressor motor; K, 115-v agitator motor. (For a 2-wire, 230-v power supply, see Fig. 4.) NOTE: Thermal overload elements to be rated at not more than 125 percent of full load running current for protecting 40 C rise motors and 115 percent for 50 C rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors

also increase the demand for electric power at the time of day when there are many other demands for power.

The purchase prices of the ice-bank coolers are less than those for the direct-expansion coolers of comparable capacities. The additional expense for electric service was also lower for the ice-bank system.

To meet the cooling requirements set forth by the 3A* standards, the milk must be cooled to 50 F within the first hour after the end of milking and to 40 F within the second hour after the end of milking. Furthermore, the milk temperature must not fluctuate more than ±2 F during the holding period. Some milk areas have more stringent recommendations and requirements. At present, the New York State Department of Health recommends that the milk be cooled to 45 F within the first hour after the end of milking. Most of the milk companies require the milk temperature to be at 40 F or lower prior to being picked up by the tank truck.

Since none of the bulk tanks studied in the field were loaded to their full rated capacity, they should have easily met the above standards. However, there were the following exceptions:

- While most of the installations met the requirements, some required as long as 75 min to cool the milk from 50 to 40 F instead of an hour.
- The holding temperature varied as much as 5 to 6 deg on several of the direct-expansion systems.

*Standards for Farm Holding and/or Cooling Tanks formulated by the International Association of Milk and Food Sanitarians, the U.S. Public Health Service, and the Dairy Industry Committee.

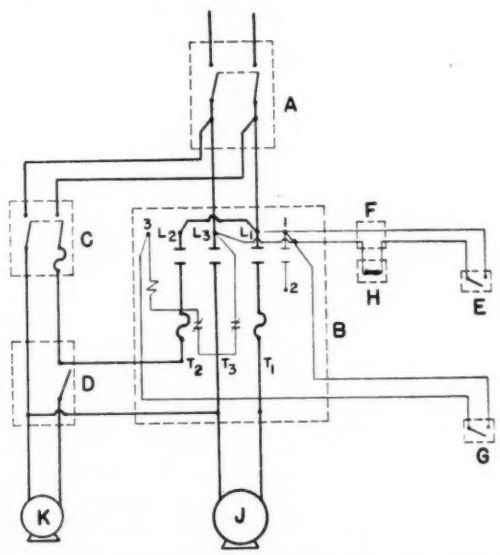

Fig. 4 Controls for a direct-expansion bulk milk cooling system with indirect thermostatic control (2-wire, 230-v). A, 2-pole safety switch; B, 3-pole 230-v magnetic starter; C, DPST thermal overload switch or safety switch with time-delay fuses normally open or "off" (a mechanical timer may be added to reduce the possibility of churning); D, SPST toggle switch normally closed or "on"; E, thermostat with start button or thermostat and mechanical timer; F, junction box; G, combination high and low pressure control; H, 230-v liquid line solenoid valve; J, 230-v compressor motor; K, 230-v agitator motor. NOTE: Thermal overload elements to be rated at not more than 125 percent of full load running current for protecting 40 C rise motors and 115 percent for 50 C rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors

- Direct-expansion systems caused freezing of the milk on several occasions. This was due largely to an incorrect type or location of the thermostatic control but also caused by improper wiring and control assemblies. The latter resulted in the condensing unit being started and left on manual operation, or, in some instances, the control assembly allowed the condensing unit to operate while the agitator was not operating. In at least two instances, frozen milk caused the agitator motors to burn out. A correct control assembly with overload protection would have prevented this expensive damage.
- Excessive churning of the milk has been experienced as indicated by the formation of butter flakes.

ELECTRIC WIRING RECOMMENDATIONS

While a few problems were observed on the location and installation of the bulk cooling tanks and related equipment, there seemed to be a greater need for more adequate wiring and control equipment. Unsatisfactory operation of the bulk cooler could be more often attributed to the electric wiring and control system than to any other factor. Therefore, considerable emphasis has been placed on this problem for New York state.

In the following discussion of a safe and economical power supply and control system, each part will be considered in view of observed field problems and our recommended solution.

Electric Service Entrance

The electric service for the bulk milk cooler branch circuit may be in the milkhouse, but on most New York state farms this main service is in the dairy barn. Most of the large compressor motors of the direct-expansion systems required a change to a larger capacity branch circuit from the barn service, and in many cases required a change in the size of the main service itself. The ice-bank systems did not present these problems as the power requirements of the bulk cooler and the can coolers, which they replaced, did not differ sufficiently to necessitate a change in branch circuit capacity. The ice-bank systems also have a better diversity factor.

Bulk Cooler Branch Circuit Wire and Fuses

Each bulk milk cooler should be installed on a separate branch circuit with the wire size selected to prevent more than a two percent voltage drop when all motors are operating. Synthetic rubber or plastic-covered non-metallic cables are recommended in preference to electrical metallic tubing to avoid deterioration from corrosive fumes and moisture.

The maximum allowable motor branch circuit fuse size must not be more than 300 percent of the full load running current of the largest motor plus 100 percent of the running current of each additional motor to conform to the National Electrical Code for short-circuit protection of the cable. Time-study fuses will often be more suitable than standard fuses on these circuits.

The power supply for the truck pump motor should also be on a separate branch circuit originating at the main service whether located in the milkhouse or in the dairy barn; these motors are commonly one horsepower in size which will require 230 v and at least No. 12 conductors. A 3-wire cable with one grounding conductor should terminate in a 3-pole twist-lock receptacle near the outside milkhouse door for the

pump motor attachment plug. If the receptacle is located outside the milkhouse, it should be of the weatherproof type.

CONTROL EQUIPMENT RECOMMENDATIONS

The control panel (Fig. 2) must be located in the milkhouse and preferably close to or on the bulk milk tank. The term "control" is intended to include overload protection devices even though they may not all be located on the main control panel. The panel should have a disconnect safety switch that will serve to cut off the power supply from all the controls and motorized equipment irrespective of the type of cooling system used. No fuses are required in this switch if the branch circuit wiring is properly fused at the main service.

Due to the variations in the three major types of refrigerating system controls each will be discussed separately.

Ice-Bank System

The compressor motor is controlled independently from the agitator and chilled-water circulating pump (Fig. 5). A separate fused safety switch protects the motor and control circuit and provides a means of disconnecting them from the power supply. A thermostat with the sensing element in the ice-bank chamber controls the compressor operation and regulates the size of the ice bank. A thermal overload switch correctly rated protects the compressor motor from possible burn out. This should be a two-pole switch but may have one thermal tripping element for a 230-v motor. Other suitable means of protecting this motor may be provided by incorporating current-limiting devices in the motor or in a relay starter supplied by the manufacturer.

The agitator motor and circulating pump motor control circuits are protected and may be disconnected with a fused safety switch. The operation of these two motors is automatically controlled by a thermostat with the sensing element in a well attached to the side of the milk-tank liner. A single-pole, single-throw toggle switch by-passes the thermostat for manual operation. This is needed to operate the agitator prior to taking a milk sample and for blending the cream layer prior to adding the second or subsequent milking to cold milk already in the tank.

A single-pole, single-throw toggle switch allows the agitator motor to be turned off while the pump circulates the chilled water to precool the tank, and prior to the time when there is sufficient milk in the tank to cover the agitator blades. Some agitators need 20 to 30 qt of milk in the tank to prevent churning.

The agitator and water-circulating pump motors are protected from overload by individually sized thermal elements in the same thermal overload switch. This switch also provides interlocking protection to stop the agitator motor in the event that the circulating pump motor should be stopped by its protective element. This will prevent excessive churning of the milk.

The thermal overload element for the compressor motor can be rated for not more than 125 percent of the full load running current for protection of 40 C rise motors and 115 percent for 50 C rise motors. Higher ratings are allowed by the National Electrical Code as specified for non-hermetically sealed refrigeration motors. The overload elements for the agitator and water-circulating pump motors can be rated for not more than 125 percent of the full-load running current for 40 C rise motors and 115 percent for 50 C rise motors.

Direct-Expansion—Direct Thermostatic Control System

The compressor motor and the agitator motor are automatically or manually controlled together through a magnetic starter and a thermostat (Fig. 3) with the sensing element in a well attached to the side of the milk-tank liner. On the larger units a high, a low, or a combination high-and-low refrigerant pressure switch is often used and connected in series with the thermostat in the magnetic starter control coil circuit. This pressure switch acts as a safety control in the event that an abnormally high head pressure or abnormally low suction pressure occurs in the system. For manually starting the cooling system, a thermostat with a mechanical start button is recommended. Once the system is started manually with the start button, the thermostat reverts to automatic operation as soon as the milk temperature rises above the thermostat setting. This prevents freezing of the milk should the cooling system be accidentally left on manual control. A mechanical timer may be used to by-pass a standard thermostat for semimanual operation but these are more complicated and more subject to failure.

On dry-type evaporators a liquid-line solenoid valve is connected in parallel with the compressor motor circuit to stop the flow of refrigerant to the expansion valve when the condensing unit is shut off.

A separate manual control to bypass the magnetic starter is used to operate the agitator motor independent of the condensing unit. This is desirable to avoid operating the large condensing unit each time a milk sample is collected or to blend the cold milk before adding warm milk. By the use of a thermal overload switch, overload protection can be provided during manual operation. A mechanical timer

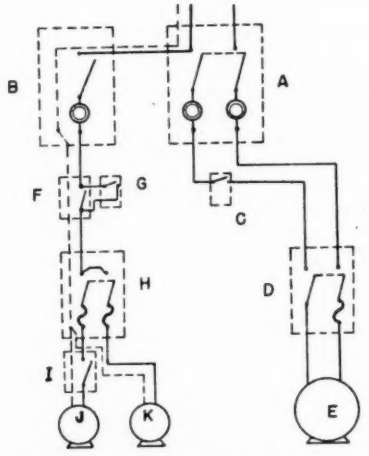

Fig. 5 Controls for an ice-bank, bulk milk cooling system (3-wire-115/230-v). A, 3-pole SN safety switch, 115/230 v; B, 2-pole SN safety switch, 115-v; C, ice-bank thermostatic control; D, thermal overload switch or built-in overload protection on the motor; E, 230-v compressor motor; F, SPST toggle switch or mechanical timer; G, thermostat for water-circulating pump and agitator motor; H, DPST thermal overload switch for interlocking control and protection on both motors; I, SPST toggle switch normally closed or "on"; J, 115-v agitator motor; K, 115-v water circulating pump motor. NOTE: Thermal overload elements to be rated at not more than 125 percent of full load running current for protecting 40 C rise motors and 115 percent for 50 C rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors

placed in the circuit either before or after the thermal switch would provide timed manual operation of the agitator to prevent excessive agitation or churning of the milk.

With a 3-pole magnetic starter, a thermal element in one pole of the starter provides overload protection for the compressor motor. The second pole of the starter completes the circuit for the control of the compressor motor. The third pole of the magnetic starter with a thermal element provides overload protection for the agitator motor and simultaneous operation with the compressor motor.

The 3-pole starter wired as shown in Figs. 3 and 4 not only provides overload protection for each motor but also provides an important dual interlocking protection. If the compressor motor becomes overloaded, its protective element will open the magnetic starter coil circuit and stop both motors, thus preventing continuous agitation of the milk without cooling. Conversely, if the agitator motor becomes overloaded, its protective element will open the starter coil circuit and stop both motors thus preventing compressor operation without agitator operation which would freeze the milk.

This control panel can be easily adapted to a 3-wire 115/230-v power supply but the 2-wire 230-v power supply is recommended. The higher voltage allows the use of smaller wire, helps motors to start easier, and ensures a better balance in the farm wiring system.

The thermal overload elements can be rated the same as described for the ice-bank systems.

Direct-Expansion—Indirect Thermostatic Control System

With the indirect thermostatic control system, the thermostat operates a solenoid valve in the refrigerant line (Fig. 4). When the thermostat contacts close, the solenoid valve opens permitting liquid refrigerant to pass into the evaporator under the milk tank. A low-pressure switch mounted on the condensing unit controls the operation of the compressor and the agitator motor through the magnetic-starter coil circuit. When the vaporizing refrigerant builds a pressure in the low side (suction line), the pressure switch activates the magnetic starter for compressor and agitator motor operation. When the milk temperature falls, the thermostat contacts open, the solenoid valve closes, shutting off the flow of refrigerant to the evaporator. As the evaporator pressure lowers sufficiently, the pressure switch opens the magnetic starter coil circuit to stop the compressor and agitator motors.

Manual starting of the cooling system can be accomplished by a thermostat with a mechanical start button or a thermostat and mechanical timer the same as with the direct thermostatic control system.

A separate manual control for the agitator motor used to by-pass the magnetic starter can be provided with a thermal overload switch the same as that described for the direct-control system.

Both the thermal overload and the interlocking protection for the compressor and agitator motors is provided in the magnetic starter the same as for the direct thermostatic control system.

This control assembly can be used for either 3-wire 115/230-v or 2-wire 230-v power supply. The higher voltage is recommended for the same reasons described for direct thermostatic control systems.

The acceptance of these more adequate and flexible wiring and control assemblies by the manufacturers of bulk milk cooling equipment, the agencies installing the systems, and the electric power suppliers would solve many of the operating problems that now represent the majority of bulk cooling difficulties on farms.

Thermal Destruction Design

(Continued from page 246)

the wiring diagram. However, in order that comparable accuracy can be had at short as well as longer time intervals, three cycle timers with ranges of 0 to 20 sec, 0 to 120 sec and 0 to 20 min are employed. When an automatically timed cycle is used, the samples are loaded into the machine, the cover closed, and the push button pressed to actuate the mechanism to pull the samples into the steam chamber. The cycle timer starts when the samples are exposed to the steam and activates the solenoid to withdraw the samples about 0.005 min before the indicated exposure time is up. It requires 0.005 min to complete the withdrawing cycle. About 0.010 min before exposure is complete, the solenoid valve controlling the sterile compressed air is opened to insure transfer of the samples to the recovery tubes without loss from ebullition. As the samples come out, they drop into the recovery tubes where they are cooled by quenching. The actual length of exposure is measured by a Precision§ timer, smallest division 0.001 min, with an accuracy of $\pm$0.0002 min. The timer is operated by microswitches and an interlocking relay, illustrated in Fig. 4. The microswitches are operated by a lever from the pneumatic cylinder rod.

SUMMARY

The design, construction, and operation of an apparatus made specifically for studying the time-temperature effects on bacterial spores and chemical compounds have been discussed. This machine has been in use for two years during which time more than 30,000 tests have been run. The results of some of the work have been reported by Pflug and Esselen (5) and (6). The apparatus has a production rate of more than 170 samples per hour, when the exposure times are less than 0.30 min.

REFERENCES

1 American Can Company. The Canned Food Reference Manual, 3rd Ed., New York, 638 pp. (1947).

2 Bigelow, W. D. and Esty, J. R. The thermal death point in relation to time of typical thermophilic organisms. *J. Infectious Diseases*, 27, 602 (1920).

3 Pflug, I. J. An apparatus for determining the thermal resistance of bacterial spores. (M.S. thesis, University of Massachusetts, Amherst, 35 pp., 1950).

4 Pflug, I. J. Thermal resistance of bacterial spores at high temperatures (Ph.D. thesis, University of Massachusetts, Amherst, 116 pp., 1953).

5 Pflug, I. J. and Esselen, W. B. Development and application of an apparatus for study of thermal resistance of bacterial spores and thiamine at temperatures above 250 F. *Food Technology*, 7, 237 (1953).

6 Pflug, I. J. and Esselen, W. B. Observations on the thermal resistance of Putrefactive Anaerobe No. 3679 spores in the temperature range 250 to 300 F. *Food Research*, 19, 92 (1954).

7 Schmidt, C. F. A method for the determination of the thermal resistance of bacterial spores. *J. Bact.*, 59, 433 (1950).

8 Stumbo, C. R. A technique for studying resistance of bacterial spores to temperatures in the higher range. *Food Technology*, 2, 288 (1948).

9 Williams, C. C., Merrill, C. M., and Cameron, E. J. Apparatus for determination of spore-destruction rates. *Food Research*, 2, 369 (1937).

§Manufactured by Standard Electric Time Co., Springfield, Mass.

Methods for Grain Moisture Measurement

Lawrence Zeleny

MOISTURE content is one of the most important factors affecting the quality of grain. Since the amount of dry matter per unit weight of grain bears an inverse relationship to the amount of moisture it contains, moisture content is a matter of direct economic importance. Of even greater significance, however, is the effect of moisture on the keeping quality of grain. Dry, sound grain, if properly stored, may be kept for years with little deterioration in quality, but wet grain may spoil completely within a few days. It is not possible, however, to set precise moisture limits for the safe storage of grain or to predict accurately how rapidly it will deteriorate at any given moisture content, because various factors other than moisture have marked effects on storage behavior. Nevertheless, under practical storage conditions, moisture content is usually the principal factor governing the keeping quality of grain. Suitable methods for determining moisture content are therefore of considerable practical importance.

Methods used to determine moisture in grain may be classified in a general way as follows:

- Oven drying methods
- Drying with desiccants
- Distillation methods
- Chemical methods
- Methods based on relative humidity measurement
- Electric moisture meters.

These various classes of moisture-testing methods will be discussed individually.

OVEN METHODS

The most widely recognized methods for determining moisture in grain are based on drying known weights of grain in various types of ovens and calculating moisture content from the weight lost in the drying operation. These methods appear to be rather simple and direct and usually constitute the "basic" methods against which rapid, practical moisture-testing equipment is calibrated. Actually, however, all oven methods for determining moisture in grain are more or less empirical in nature, the results depending on the degree of subdivision of the material being tested, and the time, temperature, and atmospheric pressure under which the drying is accomplished. In most biological materials, including grain, it is difficult if not impossible to remove all moisture by the application of heat without at the same time driving off small amounts of other volatile substances or causing decomposition of some of the constituents with the formation and release of moisture not initially present as such.

The difficulty encountered in removing all moisture from biological material, even when it is finely ground, seems to be due principally to the fact that the water is present in different forms. When an inorganic material such as wet sand is heated at 100 C or higher at atmospheric pressure, the moisture is lost at a rapid and essentially uniform rate until the material is completely dry. In drying finely ground grain, however, a much longer time is required to remove the moisture, the rate of moisture loss decreases rapidly as the drying progresses, and the ultimate loss in weight differs with different temperatures employed for drying. These facts can be readily visualized from the results of a simple experiment shown graphically in Fig. 1.

In biological materials such as grain, part of the moisture present appears to be tightly held or "bound" by powerful physical forces to proteins, high molecular weight carbohydrates, and perhaps other colloidal substances. This moisture, sometimes spoken of as "bound" water, is much more difficult to remove than the "free" water. The tenacity with which water may be held to colloidal substances probably varies with the nature of the colloidal material and with the amount of water so held. Thus in the case of wet grain there are probably encountered all gradations between "free" water that is removed by heat as readily as the water from wet sand, and water that is so tightly held that it can be removed only under conditions of temperature and pressure that may permit volatilization or decomposition of other constituents. For these reasons oven methods as well as most other "basic" methods for determining moisture in grain are actually empirical and to obtain comparable results standard procedures that have been rather arbitrarily established must be followed precisely.

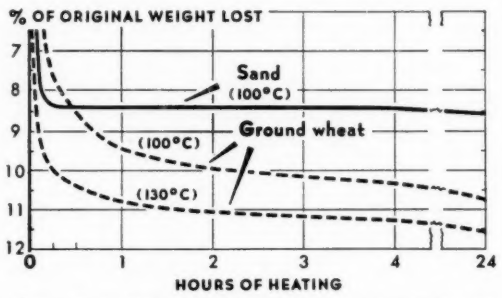

Fig. 1 Loss of weight in sand and ground wheat on heating

Air-Oven Methods. A method in which a weighed portion of finely ground grain is heated in an air oven for 1 hr at 130 C, and the loss of weight determined is widely used for determining moisture in cereal grains and is the basic method specified for grains other than corn in the official grain standards of the United States (19)*. If the initial moisture content of the grain is in excess of 13 percent, a two-stage procedure is used in which a weighed portion of grain is partially dried to a moisture content of less than 13 percent before grinding, and the loss of weight in this preliminary drying is determined. The partially dried grain is then ground and a weighed portion of the ground material is dried for 1 hr at 130 C. In calculating the moisture content the moisture losses in both stages of the procedure must be taken into consideration.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Farm Structures and Rural Electric Divisions.

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*Numbers in parentheses refer to the appended references.

Another commonly used air-oven method for determining moisture in grain provides for heating a weighed portion of the finely ground grain for 2 hr at 135 C. This method gives slightly higher results than the previously described method and is an official method of analysis for grain of the Association of Official Agricultural Chemists (1).

In addition to the conventional types of air oven, special types of air ovens are available which have built-in balances for weighing dried samples while they are still hot and without removing them from the oven. In some instances the balances may be used also for the initial weighings and are calibrated directly in terms of moisture percentage so that when the proper weight of sample is used no calculation is required.

Various other modified air-oven methods using special items of equipment have been devised to shorten the time required by standard oven methods. In general these methods provide for heating the material to considerably higher temperatures than those employed in the usual oven methods. Heating may be accomplished by ordinary electric heating coils, by radiation from infrared lamps, or by means of a high-frequency, high-voltage field (4). In employing these methods and devices, it is customary to determine in advance the time of heating and the temperature or other adjustment of the equipment required for each type of material to be tested in order to obtain results in reasonably good agreement with those obtained by one of the more "basic" methods.

Water-Oven Method. Under the official grain standards of the United States a water-oven method (19) is specified as the official basic method for the determination of moisture in corn. A weighed quantity of whole corn is dried for 96 hr at a temperature of 99 to 100 C in a water-jacketed oven in which the water is maintained at the boiling temperature. The water oven is essentially an air oven except that it is heated by means of boiling water.

Vacuum-Oven Method. One of the most widely accepted methods for determining the moisture content of grain is based on drying the finely ground grain at a temperature of 98 to 100 C in an oven chamber maintained at a pressure of 25mm or less of mercury. Heating is continued until no appreciable further loss of weight occurs (usually about 5 hr). This method is one of the official methods of the Association of Official Agricultural Chemists for grain (1) and gives results in reasonably good agreement with the 1-hr, 130 C air-oven method.

DRYING WITH DESICCANTS

The moisture content of grain and other materials may be determined by placing a weighed portion of the finely ground material in a closed container with a relatively large quantity of an efficient desiccant. The desiccant chosen must have a lower vapor tension than the material being dried. The moisture in the material is gradually vaporized, and is then absorbed by the desiccant. Moisture content is determined by the loss in weight of the original material after it finally attains constant weight. Reducing and maintaining the atmospheric pressure in the container to a low level will greatly reduce the time required to complete the operation, but even when this is done the time required is too great for most practical purposes. However, in one of the official methods of the Association of Official Agricultural Chemists for determining moisture in grain, the finely ground material is held under vacuum in the presence of anhydrous sulfuric acid until constant weight is attained (1). One advantage of the method is that it does not involve the hazard of possible decomposition of organic material by heat. However, grain of high moisture content may decompose as a result of the action of molds and bacteria before the moisture content is reduced sufficiently to inhibit the growth of these organisms.

DISTILLATION METHODS

Moisture may be removed from grain by heating the grain in oil or other non-aqueous liquid and measuring either the loss of weight or the volume of water condensed from the water vapor distilled from the grain. Several methods based on this principle are in use.

Toluene Distillation Method. One of the official methods of the Association of Official Agricultural Chemists (1) provides for boiling the finely ground grain in toluene in an apparatus that condenses the volatilized materials, collects the condensed water in a graduated tube and returns the condensed toluene to the boiling flask. The boiling is continued as long as any water accumulates in the graduated tube, and the moisture content of the grain is calculated from the volume of water condensed. Since the boiling point of toluene is 111 C, all substances that boil at or below this temperature, including all water that will be released at this temperature, are distilled. Also, since the water is measured volumetrically, no water-insoluble volatile material can be measured as moisture.

The Brown-Duvel Distillation Method. For many years moisture content was determined in the routine inspection of grain by heating a weighed portion of unground grain in oil. The moisture volatilized by this heating is condensed, then collected and measured in a graduated cylinder. The apparatus used for this purpose must be standardized to provide a definite amount of heat in a definite period of time. The method is highly arbitrary and the exact procedure to be followed must be established for each kind of grain in order to obtain results equivalent to those obtained by the applicable official oven method. The method was first proposed by Brown and Duvel (3) and the procedure to be followed for each kind of grain is described in detail in U. S. Department of Agriculture Bulletin No. 1375 (5).

The Brown-Duvel method has been largely replaced by electric moisture meters in the routine inspection of grain in the United States, but it is still used under various conditions of testing in which electric meters cannot be depended upon to give reliable results.

The Dexter Oil Distillation Method. A very simple distillation method for determining moisture in grain has been proposed by Dexter (7). The weighed sample is immersed in vegetable oil and heated to a temperature of 190 C. Moisture is determined from the loss in weight of the mixture of grain and oil. Although little use appears to have been made of this method, it has the advantages of simplicity and low cost of equipment and should prove useful on farms where a quick inexpensive method for determining the approximate moisture content of grain and other crops is desired.

CHEMICAL METHODS

From a theoretical standpoint it would appear that the most accurate measure of the true moisture content of any material might well be based on some stoichiometric chemical reaction in which water is one of the reactants. Two such reactions are the bases of methods for determining moisture that have found limited application in the testing of grain.

Calcium Carbide Methods. Calcium carbide reacts readily and completely with water to form calcium hydroxide and acetylene gas. Parks (16) was the first to utilize this reaction as a basis for determining the moisture content of plant materials. An excess of calcium carbide is mixed with a definite weight of plant material. The moisture in the material being tested reacts with the calcium carbide and the acetylene gas formed escapes from the mixture. The moisture content of the material is then calculated from the weight lost as a result of the escaped gas. A special balance for making the weighings was devised with which the final reading is made directly in terms of percent moisture. Although the method is theoretically sound, practical difficulties appear to have prevented any extensive use of it in testing grain.

A moisture-testing device based on the calcium carbide reaction is manufactured in England. The material to be tested is mixed with calcium carbide in a tightly sealed, heavy metal container equipped with a pressure gage. For any given type of plant material the pressure developed by the evolution of acetylene gas is proportional to the moisture content of the material. This method and equipment is said to be in limited use for measuring the moisture content of grain.

Karl Fischer Method. In recent years considerable attention has been given to the method of Karl Fischer (9) for determining the moisture content of a wide variety of materials. The method depends upon the reaction of iodine with water in the presence of sulfur dioxide and pyridine to form hydriodic acid and sulfuric acid. Since the method is strictly stoichiometric, it is, theoretically at least, one of the most accurate methods for determining moisture. In applying the method to grain, the grain must first be finely ground and the moisture extracted with anhydrous methyl alcohol. Because of certain practical difficulties in its application, the Karl Fischer method has been used but little in determining moisture in grain, although Fosnot and Hamon (10) seem to have applied the method successfully to wheat and barley.

Frediani (11) has recently devised an ingenious electrically operated, automatic titration device for determining moisture by the Karl Fischer method. The equipment is now available commercially.

Dichromate Method. A method for measuring the moisture content of fruits and vegetables based on oxidation of the organic material by potassium dichromate has been proposed by Launer and Tomimatsu (14). An excess of dichromate is used in the reaction and that part of it that remains after the oxidation is complete is determined by titration. A "dichromate factor" is established for each type of product to be tested and is based on results obtained by a standard oven method for determining moisture. Although the method is intended primarily for products of high moisture content, it was shown to be applicable to rice containing from 10 to 15 percent of moisture (18).

METHODS BASED ON RELATIVE HUMIDITY MEASUREMENT

When grain is freely exposed to the air it will gradually lose or gain in moisture content until it reaches a moisture content level in equilibrium with the relative humidity of the air to which it is exposed. Likewise the interstitial air in unventilated stored grain will tend to become stabilized at a relative humidity in equilibrium with the moisture content of the grain. Thus after this equilibrium is established a measurement of the relative humidity of the interstitial air may be used as an index of the moisture content of the grain. Actually such relative humidity measurements may be better indexes of the keeping quality of grain than direct moisture-content measurements, since the activity of molds and other micro-organisms that develop on or near the surfaces of grain kernels and that are largely responsible for grain spoilage is probably more closely dependent upon the relative humidity of the surrounding air than upon the moisture content of the grain. It has been shown by Milner and Geddes (15) that the rate of mold development on grain is quite slow when the relative humidity is below 75 percent, but that rapid deterioration as a result of mold growth is likely to occur at ordinary temperatures if the relative humidity of the interstitial air is greater than 75 percent. For long storage the moisture content should be low enough so that the relative humidity is considerably below 75 percent, probably below 65 percent.

Wet- and dry-bulb thermometers have been used by Gaus, Shaw, and Kliever (12), to determine the moisture content of seed cotton prior to ginning by measuring the relative humidity of air drawn by suction from bulk lots of the product. Dexter (8) has applied the wet- and dry-bulb technique to small samples of grain and other agricultural products, using saturated salt solutions rather than water on the bulb of the wet-bulb thermometer. Manufacturers of electric hygrometers are investigating the application of these devices to the measurement of moisture in grain and other products.

Ives (13) has made ingenious use of dew-point depression as a measure of relative humidity in a closed jar of grain and hence of the moisture content of the grain.

Certain inorganic salts, notably those of cobalt, undergo marked changes in color at different relative humidity levels as a result of differing degrees of hydration. Practical use of this phenomenon has been made by Solomon (17) in estimating the relative humidity of air in small spaces and by Dexter (6) in estimating the moisture content and keeping quality of grain and other farm products. Although the accuracy of any such method is not high, its simplicity may make it quite valuable for farm use.

In order to translate relative humidity measurements into terms of grain moisture content, it is obviously necessary to know the relationship between relative humidity and grain moisture. This relationship differs for different kinds of grain, and to some extent among different lots of the same kind of grain probably because of the effect of hysteresis and of differences in the tenacity with which part of the water is held by colloidal constituents. Although various investigators have published data in respect to these relationships, there is a considerable amount of disagreement

among the published reports. This whole subject is now being carefully reviewed and studied by the Northern Utilization Research Branch, USDA Agricultural Research Service.

ELECTRIC MOISTURE METERS

Certain electrical properties of grain depend largely on its moisture content and have been used as the basis for a considerable number of devices for determining moisture content.

The possibility of determining the moisture content of grain by resistance measurements was first demonstrated by Briggs in 1908 **(2)**. Using as electrodes 12-in brass rods inserted into a jar of wheat, and measuring with a Wheatstone bridge the resistance of the wheat to the flow of current from an electromotive force of 17 v, he found a linear relationship between the moisture content of the wheat and the logarithm of its resistance over the moisture range of about 11 to 16 percent. He also showed the effect of temperature on the electrical resistance of wheat.

In 1909 Zeleny **(20)** devised an electrical instrument for determining the moisture content of corn. Electrodes in the form of spaced metal points were pressed into the germs of individual kernels of corn. The two electrodes were of dissimilar metals so that with the corn kernel they formed a simple voltaic battery. The current produced depended upon the moisture content of the corn and was registered on a sensitive galvanometer. Thus no battery or other external source of current was required. In a later modification of the instrument a battery was added to the circuit and the electrodes were both made of the same metal, so that the galvanometer deflection became essentially a measure of conductivity of the corn kernel.

Although neither the Briggs nor the Zeleny devices were used extensively for practical purposes, they stimulated interest in electric grain moisture-testing and were the forerunners of a considerable number of electric moisture meters that are now widely used in the grain trade. Most of the modern meters are based on conductance or capacitance measurements†. Methods based on the use of such meters are strictly empirical and the meters must be calibrated against an appropriate "basic" method for determining moisture. Generally speaking, separate calibrations are required for each kind of grain and often for individual classes of a single kind of grain. Temperature corrections must be applied when tests are made at temperatures other than that for which the calibration is established. Because of the inherent errors in electrical methods of measuring moisture in grain a satisfactory calibration for any kind or class of grain should usually be based on tests of at least several hundred samples, covering a wide range in moisture content and produced in widely scattered areas over a period of several crop years.

Since electrical properties of grain are infiuenced by many factors other than moisture content, some of which are not fully understood, no electric moisture meter can be expected to give fully reliable results under all circumstances. Nevertheless, some of these meters, if properly calibrated, will usually give results which, when properly corrected for temperature, are sufficiently accurate for most practical purposes. Electric moisture meters are of great practical importance and are widely used because of their simplicity and speed of operation.

Conductance-Type Moisture Meters. In conductance-type moisture meters the grain is pressed between two electrodes connected in series with a suitable source of current and a galvanometer. A series of fixed resistors may be introduced individually into the circuit so that the full range of the galvanometer may be utilized for separate relatively narrow ranges in moisture content.

In one style of conductivity meter a weighed or measured portion of grain is pressed to a standard thickness between two electrodes in a small cylinder. In another style of meter, widely used in the inspection of grain under the official grain standards of the United States, the electrodes are in the form of corrugated steel rolls, one of which is motor driven. The grain, which need not be weighed or measured, is simply poured between the two rolls, which are accurately spaced with respect to each other, and which then rotate in opposite directions and subject the grain passing between them to high pressure.

Conductance-type moisture meters are relatively easy to keep in proper adjustment and to maintain in satisfactory alignment with one another. They are likewise very rapid in operation, particularly the style of meter using motor-driven electrodes. One of the principal disadvantages of conductance meters is that their accuracy is dependent in large measure upon a normal distribution of moisture within the kernels of grain. Grain that has recently been dried artifically gives low readings since the surfaces of the kernels are abnormally dry in respect to the moisture content of the grain as a whole. Likewise freshly tempered (moistened) grain gives high readings because of an excess of surface moisture. Mixtures of wet and dry grain and grain that is musty or sour also often fails to give normal readings with conductance-type meters. Furthermore, conductance meters are quite limited in the range in grain moisture content that they will measure. At moisture levels below about 7 percent, moisture in grain appears to be so tightly "bound" that it contributes very little to the conductivity, hence no satisfactory readings may be obtained at such levels. At moisture levels above about 23 percent, grain conductivity is so great it increases but little with further increase in moisture content. At these moisture levels, therefore, conductance meters are subject to serious errors.

In spite of the many shortcomings of conductance-type grain moisture meters, they will, if properly calibrated and operated, give very satisfactory results with the normal run of commercial grain. They have been used quite satisfactorily for this purpose for the past 18 years.

Capacitance-Type Moisture Meters. Since the dielectric properties of grain depend largely on its moisture content, the capacity of a condenser in which grain is the dielectric will vary in accordance with the moisture content of the grain. This principle has been utilized in the development of a number of different grain moisture meters. In some of them the circuits are so designed as to utilize the change in impedance resulting from the change in capacitance as a means of measuring the moisture content. Impedance decreases with increasing grain moisture content as a result

†A partial list of moisture-testing devices for grain and related commodities is maintained by the author and can be obtained upon request.

of the effect of the moisture on the dielectric properties of the grain.

Moisture meters of this type have certain inherent advantages over conductance-type meters. They are less subject than conductance meters to errors resulting from uneven moisture distribution within or among the kernels of the grain being tested, and to errors associated with mustiness or sourness of grain. They are also capable of testing grain over a wider range of moisture content than are conductance meters. In spite of these advantages, it has never been demonstrated that capacitance-type moisture meters are capable of greater over-all accuracy in testing the normal run of commercial grain than are conductance meters. Capacitance meters should be particularly useful, however, in testing freshly dried or tempered grain, mixtures of wet and dry grain, out-of-condition grain, and grain of very high or low moisture content.

Good replicability of results is somewhat more difficult to obtain with capacitance meters than with conductance meters, particularly in the higher moisture ranges. This appears to be due to a degree of non-uniformity in the packing and orientation of the grain kernels when they are dropped into position between the plates of the condenser. Another serious practical disadvantage encountered with many capacitance moisture meters is the difficulty in keeping them in proper adjustment, particularly in maintaining accurate alignment among individual instruments. Uniformity of results obtained among many different inspection offices is of paramount importance in routine grain inspection work. Satisfactory uniformity has been more easily attained with conductance than with capacitance meters. Marked improvements, however, are being made in capacitance meters both in respect to precision in manufacture and to means for maintaining proper adjustment and alignment.

CURRENT RESEARCH IN GRAIN MOISTURE TESTING

Several lines of research are being conducted by the Department of Agriculture that should lead to improved methods for measuring moisture in grain. The Agricultural Research Service at its Northern Utilization Research Branch is making a detailed study of the relation between grain moisture content and the relative humidity of the surrounding air. The effect of hysteresis and other factors on this relationship is included in this study. The Michigan Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture is endeavoring to develop simple and inexpensive devices and methods for measuring grain moisture that are adapted to farm use. The Agricultural Research Service is working on the development of superior moisture-testing equipment suitable for use in routine grain inspection. The Agricultural Marketing Service is endeavoring to develop more uniform and reliable basic moisture-testing methods for use in calibrating electric and other rapid moisture-testing devices used in grain inspection. It is also investigating the relative suitability of various electric moisture meters for use in practical grain inspection work.

In the industrial field, manufacturers of electric hygrometers are endeavoring to adapt these devices to the measurement of moisture in grain under practical conditions. Manufacturers of electric moisture meters, both of the conductance and capacitance types, recognizing the shortcomings of their instruments, are making important improvements that should make them more accurate and more universally adaptable.

The importance of moisture content and of practical methods for its accurate measurement in grain and other agricultural products is becoming more fully recognized. Although moisture measurement is often regarded as one of the simplest of analytical procedures, it is actually fraught with many and often unexpected complexities. Much progress has been made but much more research remains to be done.

REFERENCES

1 Association of Official Agricultural Chemists. Official Methods of Analysis. Published by the Association of Official Agricultural Chemists, P.O. Box 540, Benjamin Franklin Station, Washington 4, D.C., 7th Edition (1950).

2 Briggs, Lyman J. An Electrical Resistance Method for the Rapid Determination of the Moisture Content of Grain. U.S. Dept. of Agric. Bureau of Plant Industry Circular No. 20, 8 pp. (1908).

3 Brown, Edgar, and Duvel, J. W. T. A Quick Method for the Determination of Moisture in Grain. U.S. Dept. of Agric. Bureau of Plant Industry Bull. 99 (1907).

4 Christie, Alfred. High Frequency Desiccator. U.S. Patent No. 2,360,108 (1944).

5 Coleman, D. A. and Boerner, E. G. The Brown-Duvel Moisture Tester and How to Operate It. U.S. Dept. of Agric. Dept. Bull. No. 1375 (revised), 44 pp., illus. (1936).

6 Dexter, S. T. A Colorimetric Test for Estimating the Percentage Moisture or the Storage Quality of Farm Products or Other Dry Materials. Mich. Agr. Exp. Sta. Quarterly Bull. 30, 422-426 (1948).

7 Dexter, S. T. An Oil-Distillation Method for Determining the Moisture Content of Farm Crops. Mich. Agr. Exp. Sta. Quarterly Bull. 31, 248-253 (1948).

8 Dexter, S. T. A Modified Wet and Dry-Bulb Thermometer Technique for Determining the Moisture Content or Storage Qualities of So-Called Dry Materials. Mich. Agr. Exp. Sta. Quarterly Bull. 31, 275-286 (1949).

9 Fischer, Karl. A New Method for the Analytical Determination of the Water Content of Liquids and Solids. *Angew. Chem.* 48, 394-396 (1935).

10 Fosnot, Richard H. and Hamon, Robert W. A Preliminary Investigation of the Application of the Karl Fischer Reagent to the Determination of Moisture in Cereals and Cereal Products. *Cereal Chem.* 22, 41-49 (1945).

11 Frediani, H. A. Automatic Karl Fischer Titration. *Anal. Chem.* 24, 1126-1128 (1952).

12 Gaus, George E.; Shaw, Charles S.; and Kliever, Waldo H. A Practical Seed-Cotton Moisture Tester for Use at Gins. U.S. Dept. Agric. Circular 621, 26 pp., illus. (1941).

13 Ives, Norton C. A Dew-Point Moisture Indicator. AGRICULTURAL ENGINEERING 33, 85-87 (1952).

14 Launer, Herbert F. and Tomimatsu, Yoshio. Rapid Method for Moisture in Fruits and Vegetables by Oxidation with Dichromate. I. Potatoes and Peas. *Food Technology* 6 (2) : 59-64 (1952).

15 Milner, Max, and Geddes, W. F. Grain Storage Studies III. The Relation Between Moisture Content, Mold Growth, and Respiration of Soybeans. *Cereal Chem.* 23, 225-247 (1946).

16 Parks, R. Q. A Rapid and Simple Method for Determining Moisture in Forages and Grains. *Jour. Am. Soc. Agron.* 33, 325-335 (1941).

17 Solomon, M. E. The Use of Cobalt Salts as Indicators of Humidity and Moisture. *Annals of Applied Biology* 32, 75-78 (1945).

18 Tomimatsu, Yoshio and Launer, Herbert F. Rapid Method for Moisture in Fruits and Vegetables by Oxidation with Dichromate. II. Pineapple-Rice Pudding, Rice, Prunes, and Corn. *Food Technology* 6 (8) : 281-285 (1952).

19 U.S. Department of Agriculture. Air-Oven and Water-Oven Methods Specified in the Official Grain Standards of the United States for Determining the Moisture Content of Grain. Service and Regulatory Announcements No. 147 (revised) 3 pp. (1941).

20 Zeleny, Anthony. An Electrical Method for the Measurement of the Amount of Moisture in Grain and Other Materials. *The Minnesota Engineer* 17, 163-170 (1909).

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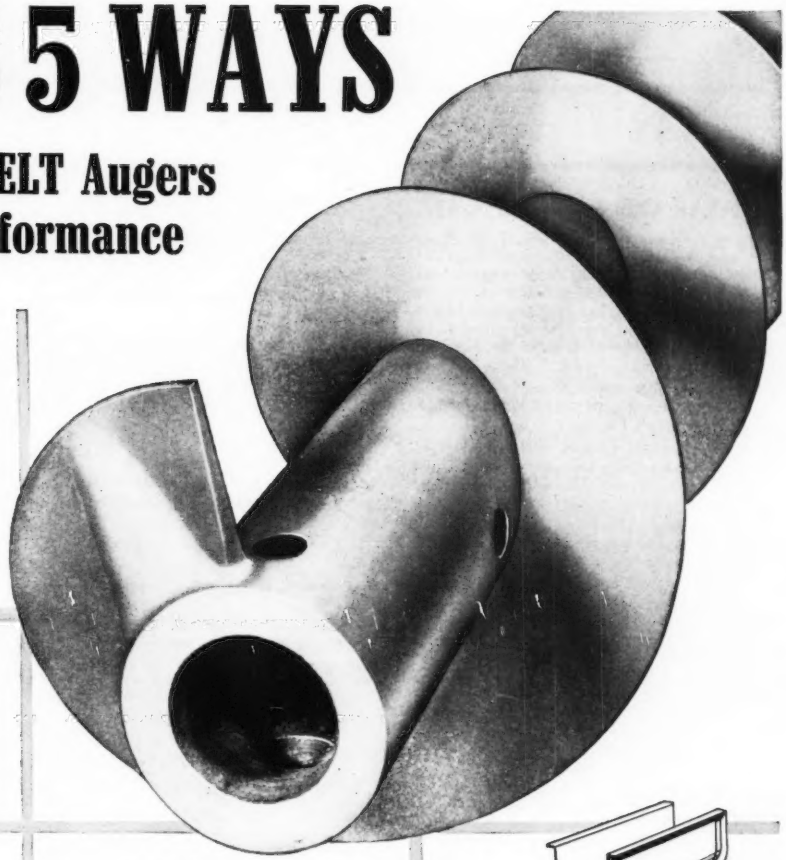

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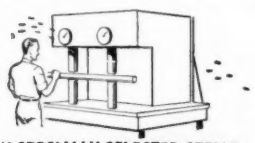

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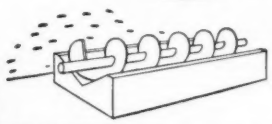

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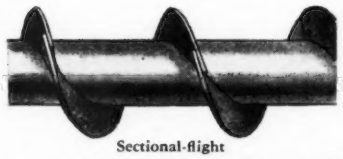

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NEWS SECTION

ASAE Officers for 1954-55

THE following new officers of the American Society of Agricultural Engineers were elected as a result of the regular election conducted by letter ballot of its corporate members during February and March, and they will take office at the close of the Society's annual meeting to be held at Minneapolis, Minn., June 20 to 23:

President—George B. Nutt, head, agricultural engineering department, Clemson Agricultural College, Clemson, S. C.

Vice-President (3-year term)—Harold H. Beaty, rural service manager, Edison Electric Institute, New York, N. Y.

Councilor (3-year term)—Richard K. Frevert, assistant director, Iowa Agricultural Experiment Station, and professor of agricultural engineering, Iowa State College, Ames.

Nominating Committee—K. W. Anderson (chairman), manager of product research, Deere & Co., Moline, Ill.; Roy Bainer, chairman, agricultural engineering department, University of California, Davis, and C. K. Otis, agricultural engineering division, University of Minnesota, St. Paul.

The members of the Council for the Society year 1954-55 will include the above newly-elected officers together with the following: Ivan D. Wood and Edwin W. Tanquary, past-presidents; L. H. Skromme and J. W. Martin, vice-presidents, and H. N. Stapleton and Harry Dearing, Jr., councilors.

Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for election of officers of the Society in the next annual election of officers which will be held in February and March, 1955. It is desirable that such suggestions reach the Nominating Committee on or before June 1, 1954.

Iowa-Illinois Section Meets April 23

THE next meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers will be held in Moline, Ill., Friday, April 23, starting at 12:30 p.m.

Those attending the meeting are requested to assemble at the John Deere Planter Works in Moline for a tour of this plant. If time permits, the group will also tour the John Deere Malleable Works.

Following the plant tours, the group will meet at The Towers in Moline for the special program arranged for the meeting, which will feature the subject of shell molding as practiced in the farm equipment industry. G. T. Phillips of the International Harvester Co. and T. L. Burkland of Deere and Co. will present papers based on the experiences of their respective companies in the application of shell molding. This will be followed by a panel discussion between students and engineers which will be all led by Carleton L. Zink of Deere and Co.

The annual Section dinner will be held at The Towers, the feature of which will be an address by ASAE President E. W. Tanquary, engineering specialist, International Harvester Co.

The annual business meeting, including the election of new officers of the Section, will complete the program.

ASAE Meetings Calendar

April 23 — IOWA-ILLINOIS SECTION, John Deere Planter Works and The Towers, Moline, Ill.

April 30 — OKLAHOMA SECTION, Clinton, Okla.

April 30 and May 1 — VIRGINIA SECTION, Natural Bridge Hotel, Natural Bridge, Va.

May 8 — MICHIGAN SECTION, Agricultural Engineering Building, Michigan State College, East Lansing

May 14 and 15 ALABAMA SECTION, McLester Hotel, Tuscaloosa, Ala.

June 20-23—47TH ANNUAL MEETING, University of Minnesota, Minneapolis

August 24-26—NORTH ATLANTIC SECTION, University of Vermont, Burlington

October 14 and 15—PACIFIC NORTHWEST SECTION, Davenport Hotel, Spokane, Wash.

December 6-8 — WINTER MEETING, Edgewater Beach Hotel, Chicago.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Farm Equipment Industry-Research Conference

A PROGRAM on which will appear many of the nation's leading agricultural engineers, farm equipment manufacturers and North Carolina's top farm officials has been announced for the Farm Equipment Industry-Research Conference, to be held at Raleigh, N. C., April 28, 29 and 30, under the joint sponsorship of the North Carolina State College agricultural engineering department and the Farm Equipment Institute.

The program includes trips to farms where representatives of the farm equipment industry and research organizations can see first hand many of the mechanization problems peculiar to such southern crops as hay, peanuts, cotton and tobacco, according to G. W. Giles, head of the NCSC agricultural engineering department. (Copies of the complete program of the conference may be obtained direct from Mr. Giles.)

Out-of-state speakers from eight states include A. W. Phelps, president of the Farm Equipment Institute and chairman of the board of The Oliver Corp.; Geo. B. Nutt, head of agricultural engineering, Clemson College; E. G. McKibben, head of USDA agricultural engineering research, and S. P. Lyle, in charge of the agricultural section, USDA Cooperative Extension Service.

Other speakers include R. M. Merrill, product research department, Deere and Co., Moline, Ill.; R. H. Driftmier, chairman of agricultural engineering division, University of Georgia; I. F. Reed, senior agricultural engineer, USDA tillage machinery laboratory; J. L. Shephard, head of agricultural engineering, Georgia Coastal Plain Experiment Station; N. C. Teter, agricultural engineer, Virginia Tidewater Field Station; Sherman E. Johnson, director, USDA farm and land management research; E. T. Swink, Virginia extension agricultural engineer, and F. P. Hanson, chairman of the FEI research committee, agricultural engineer, Caterpillar Tractor Co.

To be considered on the program of the conference are such subjects as forage crop harvesting and preservation, flue-cured tobacco mechanization the South's No. 1 machinery problem, economic aspects of mechanizing agriculture in the southeast, atomic energy and the farm equipment industry, and peanut mechanization. A half-day each will be devoted to tobacco and peanut mechanization.

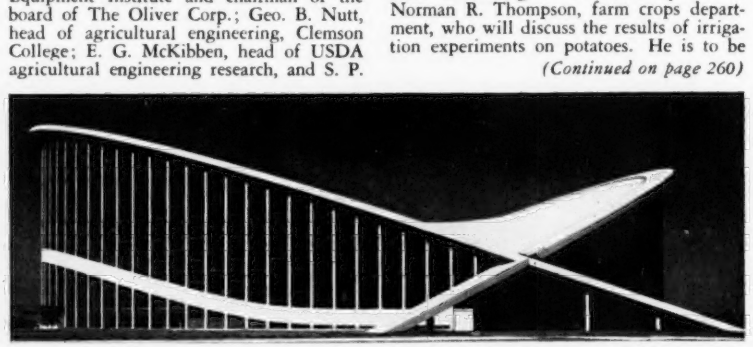
North Carolina's commissioner of agriculture, L. Y. Ballentine, will explain the state's "nickels for know-how" program, by which farmers contribute to agricultural research. State Extension Director David S. Weaver will discuss the North Carolina's long-range cooperative program for agricultural development.

Michigan Irrigation Conference

THE Michigan Irrigation Conference will be held April 22 at the Kellogg Center, Michigan State College, East Lansing. It is sponsored by the Soil and Water Section of the Agricultural Engineering Department in cooperation with the Soil Science, Farm Crops and Horticulture Departments, and the Continuing Education Service of MSC.

Chairman of the forenoon session is John R. Davis, agricultural engineering department, who will introduce A. W. Farrall, head of the department, who will welcome all visitors to MSC and to the conference. The first speaker is Milo B. Tesar, farm crops department, who will present results of experimental work on irrigation of pastures in Michigan. The next speaker is Norman R. Thompson, farm crops department, who will discuss the results of irrigation experiments on potatoes. He is to be

(Continued on page 260)



The march of farm equipment and modern architecture in the South will be combined for guests attending the Farm Equipment Industry-Research Conference at Raleigh, N. C., April 28, 29, and 30. A farm machinery display and demonstration will be held in the North Carolina state fair arena shown in this picture. This unique building has become internationally famous and is widely acclaimed for its architecture, design, and engineering

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Although new, word of the value of these feeding practices has spread rapidly, and many farmers have already successfully adapted them to their own farms and ranches.

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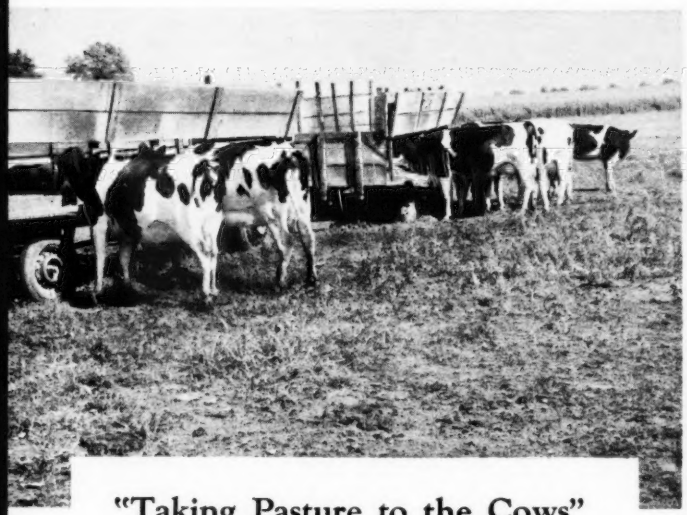
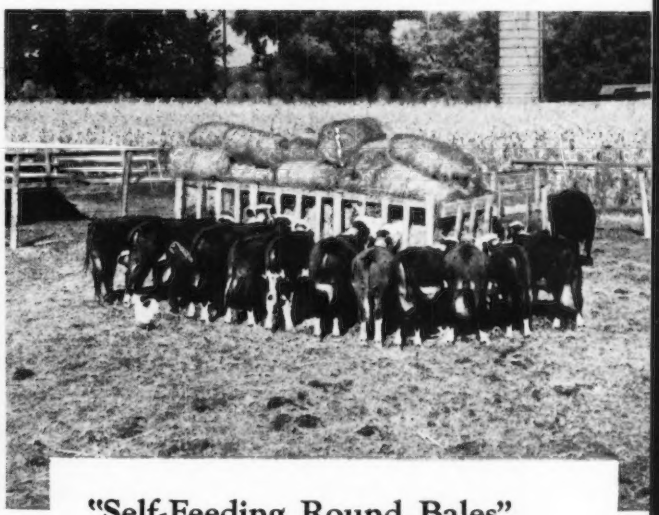


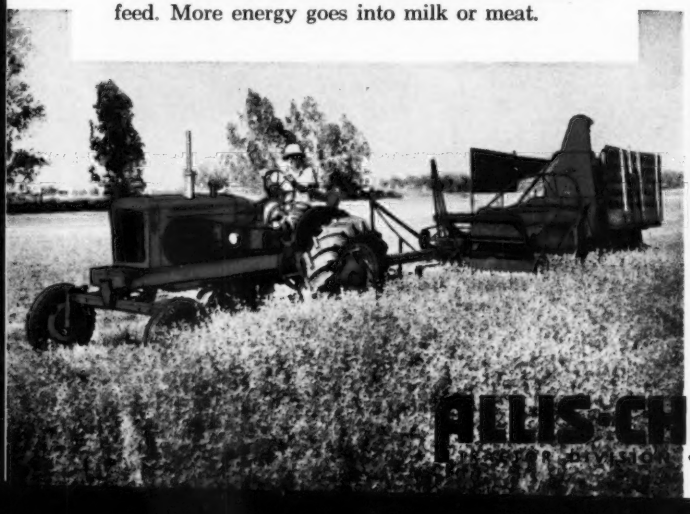
"Taking Pasture to the Cows"

In a new system of "mechanized grazing," legume or grass pasture is field-chopped and brought daily to the cattle. It can be fed fresh-cut from a self-feeding wagon, placed in bunks with a self-unloader, or ensiled for later use. Those who have tried it say pastures produce more and better forage when harvested *by machine*. There is neither hoof damage nor over-grazing. Weeds are controlled. Cattle no longer have to hunt for feed. More energy goes into milk or meat.



"Self-Feeding Round Bales"

On the ground or in the feed rack, round bales are self-feeding. As livestock eat one layer, they uncover another. The rest of the hay is still rolled inside and protected. Curved outer layers of hay keep raindrops away from the center of the bale. If left on the ground, the bale also resists soil moisture. Round bales are easily handled, hauled or stacked. They're uniform in length and pack tightly together . . . never break under rough handling.



ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, WIS.

NEWS SECTION

(Continued from page 258)

followed by Robert L. Carolus, horticulture department, who will speak on vegetable-crop irrigation in Michigan. The results of field and laboratory tests on infiltration rates and water-holding capacity of Michigan soils will then be discussed by A. Earl Erickson, soils science department.

After the noon luncheon, the chairman for the afternoon session, George Amundson, will introduce John R. Davis, agricultural engineering department, who will present recent results of experiments on irrigation for frost protection. The next speaker is the feature speaker of the day, Ivan D. Wood, ASAE past-president and irrigation engineer, USDA Soil Conservation Service. He will speak on irrigation—present and future. The third speaker in the afternoon is Lloyd L. Harrold, project supervisor, U.S. Department of Agriculture, who will present information on daily water use by irrigated and unirrigated corn in Ohio in 1953. He is to be followed by Elmer C. Rossman, farm crops department, discussing field corn irrigation studies in Michigan in 1953. The last speaker on the program is Ernest H. Kidder, who will discuss the MSC-SCS tentative irrigation guide.

Requests for copies of the printed program of the Conference, which includes a form for room and conference reservations, should be mailed to the Department of Continuing Education, Kellogg Center, Michigan State College, East Lansing.

Michigan Section Spring Meeting

THE spring meeting of the Michigan Section of American Society of Agricultural Engineers will be held in the Agricultural Engineering Building on the Michigan State College campus, East Lansing, May 8. A special effort is being made to have as many MSC agricultural engineering alumni as possible attend the meeting, an additional attraction being the "Engineering Exposition" being sponsored on the campus at that time by the institution's school of engineering. The engineering exposition is a student-sponsored and student-prepared exhibit plus industrial exhibits showing progress in engineering. The local ASAE Student Branch is taking an especially active part this year in preparing exhibits and sponsoring a midget auto race.

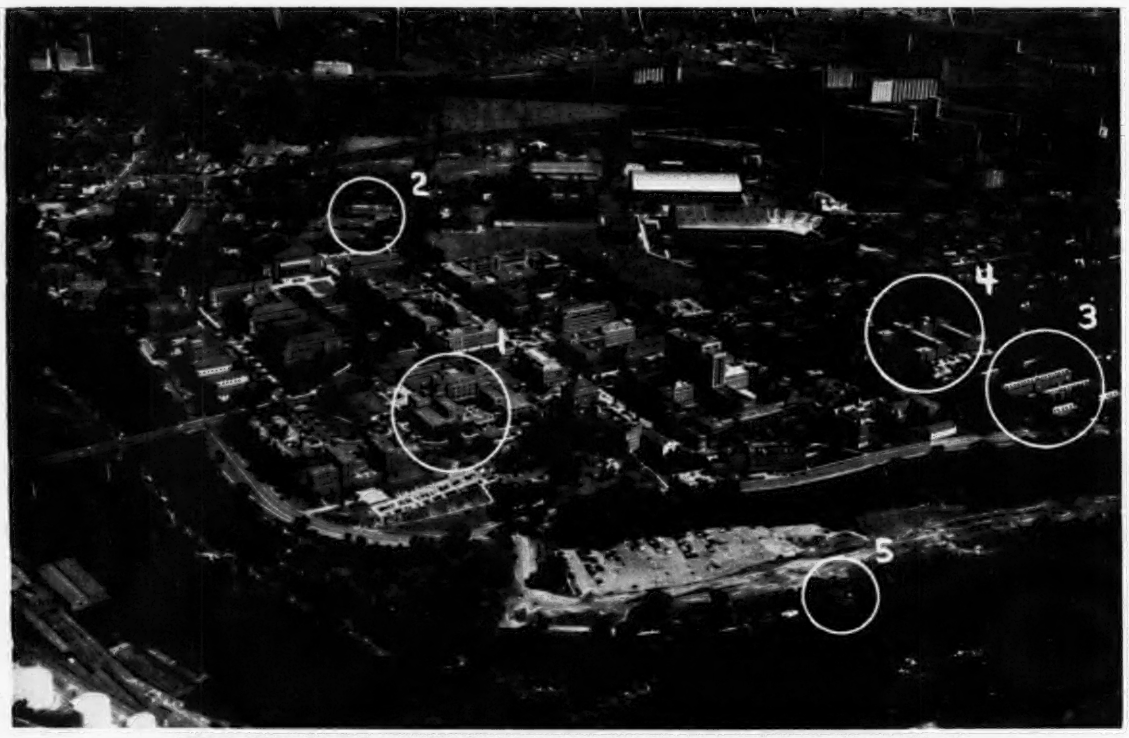
The Section program will be opened at 10:00 a.m. on the date of the meeting with the showing of a motion picture "Minnesota, The Vacationland," intended to interest those present in attending the ASAE annual meeting at the University of Minnesota in June. This will be followed by a paper to be presented by Baba Telischi, MSC agricultural engineering student, on the development of new methods to determine the relationship of the fundamental factors and draft requirements of tillage tools. A. L. Lane of the Detroit Edison Co. will speak to the group on why the electric utilities are interested in agricultural engineers. A technical paper on self-feeding vertical and horizontal silos will be presented by C. J. Mackson and W. H. Friday of the MSC agricultural engineering staff. The technical program will conclude with a presentation by John R. Davis, MSC instructor in agricultural engineering, on the water resources for Michigan agriculture.

Following the noon luncheon there will be guided tours of the MSC television studios and the exhibits of the Engineering Exposition.

Further information concerning the program may be obtained from Section Secretary E. H. Kidder, agricultural engineering department, Michigan State College, East Lansing. *(News continued on page 262)*

47th Annual Meeting -- American Society of Agricultural Engineers

June 20-23, 1954 — Coffman Memorial Union, University of Minnesota, Minneapolis



AERIAL VIEW OF THE UNIVERSITY OF MINNESOTA MAIN CAMPUS AT MINNEAPOLIS

This view of the University of Minnesota main campus is the setting for the 47th ASAE Annual Meeting in Minneapolis, June 20-23. Coffman Memorial Union (1) is the general headquarters for the meeting, and where the annual dinner will be held. The Museum of Natural History (2) is the location of the general session. Pioneer Hall (3) and Centennial Hall (4) have very moderately priced accommodations for members who bring their families to the meeting. On the Mississippi River, the river boat Donna Mae (5) will take the ladies and children on a scenic tour down to Hastings, Minn., and back. Convenient housing and access to all the activities of this meeting are but two of the reasons why this year's event is so attractive to ASAE members. Most important, of course, is the full schedule of technical program sessions planned to cover many areas of discussion on current agricultural engineering problems

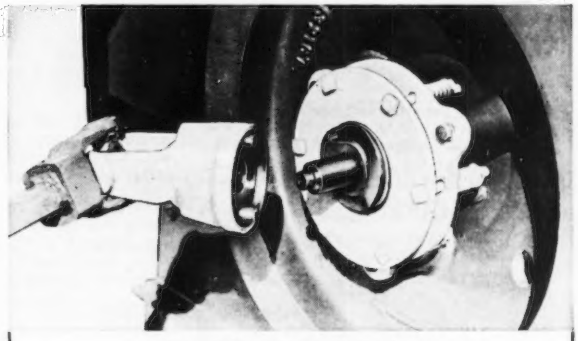
New Holland's new "66" P.T.O. bales up to 7 tons an hour with a 2-plow tractor

New *"live-action"* clutch solves P.T.O. baling's biggest problem

When you hit a heavy spot in a windrow with a p.t.o. baler, you've got to slow down to give the baler a chance to handle the extra hay. The answer is to shift down the tractor gears. On ordinary p.t.o. balers you must stop both tractor and baler motion . . . losing valuable baling time.

But here's where New Holland's new P.T.O. "66" makes a big contribution to fast, practical p.t.o. baling. For, unlike other p.t.o. machines, New Holland's live-action clutch lets you shift tractor gears up or down *without waiting for the flywheel to stop spinning.* There's no danger of flywheel momentum pushing the tractor, locking the gears or damaging the transmission. And there's no lost time—no extra work.

It's farm-engineered features like the new live-action clutch that make New Holland machines so practical to own, so easy to operate. The New Holland Machine Co., New Holland, Pa. A subsidiary of The Sperry Corporation.



How "live-action" works

It's as simple as this. Two projecting spring-loaded studs on the face of the universal joint connection, at left, mesh with the spiral cams on the clutch face, at right, during normal operation. When tractor p.t.o. stops, flywheel "coasts" by the studs. A dual disc slip clutch also protects the baler from strain in fast starts with heavy tractors or loads of bunched hay.

NEW HOLLAND *"First in Grassland Farming"*

NEWS SECTION

(Continued from page 262)

Dairy Engineering Conference

ONE hundred fifteen representatives from 15 different states and provinces of the United States and Canada attended the Second Dairy Engineering Conference held at the Kellogg Center on the Michigan State College campus on March 3 and 4.

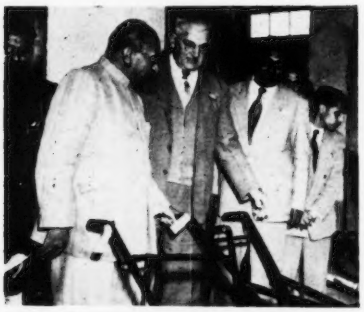
In addition to the subjects and speakers that featured the program of the conference, not included in previous program announcements, included a talk on the effect of bulk handling on plant operations by Max Jacoby, plant manager, Bay City, Mich., dairy. Water conditioning for the dairy plant was discussed by Joseph O'Dell, chemical engineer of the Lansing Board of Water and Electric Light Commissioners. E. C. Ward of the United Cork Co. talked on hardening room longevity.

The registration fee of $5.00 for the conference was intended to include a copy of the proceedings which it is understood will shortly be available. Persons who did not attend the conference, but who desire copies of the proceedings, may obtain them by writing the agricultural engineering department, Michigan State College, East Lansing, and remitting the price of $1.50 per copy.

Agricultural Engineers Responsible for Indian Implement Factory

IN FEBRUARY the Minister of Agriculture of the Government of India presided at the opening of a farm implement factory near Allahabad, India. The factory is the outgrowth of the work of the agricultural engineering department of Allahabad Agricultural Institute to provide Indian agriculture with more suitable tools and in more adequate quantities. This work has been under the direction of Mason Vaugh, a member of ASAE, as head of the agricultural engineering department of the Institute, and Mr. Vaugh has been appointed executive secretary and general manager of the new factory.

For many years the Institute's agricultural engineering department has directed its research and development program towards solving one of the greatest problems facing Indian villagers, namely, the design and building of implements which could be easily fitted into the present village situation. This means implements designed for bullock or hand power and readily transportable from field to field on the villager's shoulders or on the yoke of a pair of bullocks. It was also essential that such implements be low in initial cost and capable of easy maintenance.



In this picture the Minister of Agriculture of India, Dr. Punjabrao Deshmukh (second from left), is being shown some of the farm implements built in the new implement factory near Allahabad, by Mason Vaugh (center), general manager of the factory

The first of such implements to be produced successfully was a 6-inch moldboard plow with a long wooden beam and single handle. Afterwards four more plow designs were developed, tested and put into production along with a variety of other bullock-drawn implements including cultivators and scrapers. Among the hand-operated implements developed was a winnowing fan and a low-lift irrigation pump.

These implements have all found acceptance in India, but the ever-increasing demand has never been fully met. Before opening of the new factory, the manufacture of these implements was carried on in the workshop of the Allahabad Agricultural Institute where facilities and labor supply were inadequate. It was therefore decided to form an independent organization to be known as the Agricultural Development Society to produce and distribute these and other implements designed at the Institute. The funds for establishing the factory were donated by Indian CROP (Christian Rural Overseas Program), and many of the machine tools were obtained from war reparations stocks. It is expected that production of the factory in its first year of operation will be at least 2000 plows and 350 cultivators with an adequate number of replacement parts, also 100 winnowing fans, 100 low-lift hand pumps, 50 earth scoops, and some 2000 hand tools.

NEWS OF ASAE MEMBERS

Leonard J. Fletcher, Fellow and Past-President of ASAE, 1944 McCormick medalist, and vice-president of Caterpillar Tractor Co., was one of five distinguished engineers who were presented Missouri Honor Awards March 20 at a special convocation climaxing "Engineer's Week" at the University of Missouri.

Leonard J. Fletcher

The citation for Mr. Fletcher read as follows: "Leonard J. Fletcher in recognition of his brilliant career as an educator, both as teacher and an administrator, in agricultural engineering; his effective leadership in the improvement of engineering education and the advancement of the engineering profession; his high achievement in technical services and in industrial administration in one of our large corporations; his unusual accomplishments in the field of human and community relations, resulting in improved understandings of our American industrial economy by various segments of society—the College of Engineering and the Engineering Foundation of the University of Missouri confer upon him the Missouri Honor Award for Distinguished Service in Engineering."

By personal example and his ability to pass along information to others, Mr. Fletcher has been highly effective in extending the recognition of agricultural engineers and agricultural engineering in his numerous and nationwide contacts. In addition to his membership in ASAE, he has been active in the American Society of Mechanical Engineers, the American Society for Engineering Education, the Illinois Training Director's Society, the Chamber of Commerce of the United States, Illinois State Chamber of Commerce, and the Department of United Church Men of the National Council of Churches. He is also a trustee of Bradley University and a member of Tau Beta Pi and Pi Tau Sigma.

George E. Womble is now employed as product engineer on hydraulic equipment with the New Idea Division of Avco Manufacturing Corp. at its Fort Dodge, Ia. works.

W. D. Ellison, consultant on soil conservation and erosion control, Bureau of Yards and Docks, U.S. Navy, was elected a fellow of the Soil Conservation Society of America at its 1953 annual meeting.

Andrew Cowart, who has been employed as a district sales manager of the Stran-Steel Division of the Great Lakes Steel Corp., is now a district manager of United States Steel Homes, Inc., of Harrisburg, Pa., and is located at New Cumberland, Pa. His new work will include sales supervision and dealer organization and management.

L. Geo. Coonrod has resigned his position as assistant agricultural engineer at the Louisiana State University Rice Experiment Station at Crowley and has accepted an assignment in connection with the Point Four Program of the Foreign Operations Administration and will be located in the Middle East country of Jordan. His work will be in the field of farm machinery, soil conservation, and grain storage.

James M. Howell has resigned as city engineer at Amory, Miss., to accept a position as city engineer for West Memphis, Ark.

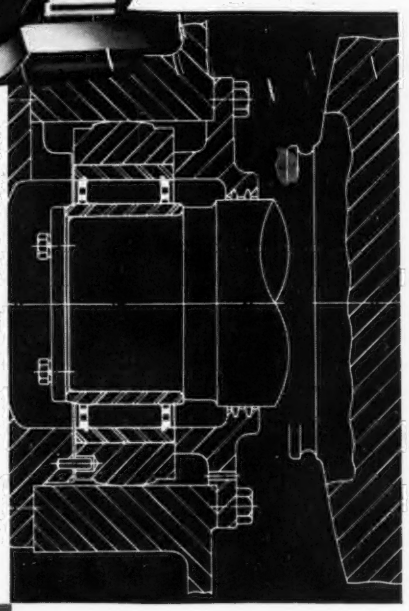
Gordon L. Nelson, who is head of the Oklahoma Farm Structures Service, a function of the agricultural engineering department at the Oklahoma A. and M. College, Stillwater, has been awarded what is believed to be the first National Science Foundation fellowship for study toward a doctorate degree in agricultural engineering. The award was won in open competition with thousands of American college and university faculty members and graduate students for the NSF fellowships this year. Mr. Nelson will begin work for his doctorate degree at Iowa State College in September and on its completion will return to his position on the Oklahoma agricultural engineering faculty. Mr. Nelson is a native of Minnesota and a 1942 graduate in agricultural engineering of the University of Minnesota. He is a veteran of 42 months of service in the U.S. Navy during World War II, during which time he completed an 18-month post-graduate course in naval engineering design at the U.S. Naval Academy. As head of the Oklahoma Farm Structures Service he has been instrumental in the design of 22 farm-fitted buildings designed specifically for Oklahoma climate and livestock.

Gordon L. Nelson

Is shaft expansion a problem?

HERE'S HOW HYATTS HELP...

Hyatt Hy-Loads are available in separable outer race, separable inner race or non-separable construction.



Check the drawing at the left. The bearing is a Hyatt Hy-Load, and because the inner race is cylindrical, the shaft it supports is free to move axially—thus allowing for shaft expansion without cramping the bearing or distorting the shaft. Obviously, this is only one of many ways in which Hyatt bearings can be used to reduce costs as they reduce friction, but it's a good example of why so many designers throughout industry keep their Hyatt catalogs within easy reach.

For further details write for Catalog 150 or call your nearest Hyatt representative.

HYATT ROLLER BEARINGS

STRAIGHT ▯ BARREL ▯ TAPER ▯

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

Power that pays off!

that's Le Roi heavy-duty power

A typical Le Roi-engine application in the farm-equipment field — powering a Papec Forage Harvester. Le Roi power is first choice of many manufacturers of oilfield, construction, industrial and agricultural equipment.

Built by a manufacturer who concentrates exclusively on the problems of the heavy-duty field

POWER you can punish. Power you don't have to pamper. Power that pays off in dependable service — in operating economy — in quick field maintenance. That's Le Roi power!

A Le Roi is no automotive lightweight — it's a power-packed, valve-in-head engine designed especially for heavy-duty service. You get the advantages of weight and stamina that stand the abuse handed out to field equipment, without costly breakdowns. And you get many features that add to the dependability and economy of operation — features that have been proved wherever tough conditions test soundness of design and quality of materials and workmanship.

Yes, sir, Le Roi is your best power buy—whether you're getting new equipment or replacement engines, or whether you're looking for an efficient power plant for the equipment you've designed. Le Roi has a full range of sizes from 15 to 635 hp — for gasoline, natural gas, butane.

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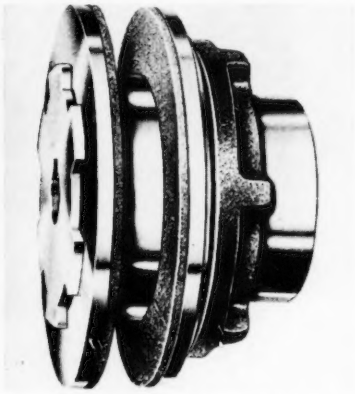
NEW PRODUCTS CATALOGS

Torque Limiter Device Announced

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich., announces a new line of compact, adjustable torque-limiting overload protection devices for a wide variety of machines, called Morse Torque Limiters. They are slip-type friction-clutch devices which feature a powdered metal bushing on which such drive components as chain sprockets, V-belt pulleys or gears can be mounted. There are 11 standard models giving maximum torque capacities from 20 to 620 ft-lb.

This torque limiter acts as an automatic shear-pin mechanism that avoids the time and labor required to insert a new shear pin. The device is torque sensitive, compact, needs no resetting and is tamperproof. Typical applications for the device include

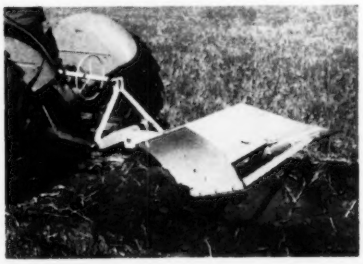


drives for conveyors, materials-handling equipment, agricultural equipment, automated machine tools, and related types of drives where overload protection is required.

Standard Morse type A plain plate roller chain sprockets fit the bushings in the various models. Since standard components have been utilized to provide the wide range of torque capacities, special designs requiring specific performance or design characteristics can be simply assembled by using many standard torque-limiter components.

Floating Hitch Ditcher

Eversman Mfg. Co., Denver, Colo., announce a third model of the Eversman floating hitch ditcher. It is known as the H-5 and is built for tractors with 3-point hitch systems. It makes possible a one-man oper-



ation in digging or cleaning ditches up to 5 feet wide by 27 inches deep. A hand-screw adjustment from the tractor seat determines the width of the ditch and the depth is regulated by the tractor lift system.

(Continued on page 266)

IMPROVE efficiency..versatility..performance

DESIGN AEROQUIP HYDRAULIC ACCESSORIES INTO YOUR FARM EQUIPMENT

AEROQUIP FLEXIBLE HOSE LINES WITH DETACHABLE, REUSABLE FITTINGS withstand extreme weather conditions. They are recommended for use with hydraulic fluids, butane, propane, lubricating oils, water, fuel, and many other fluids. Aeroquip hose assemblies can be made quickly by cutting bulk hose to required length and attaching the reusable fittings. No special tools are needed.

WITH THE AEROQUIP SELF-SEALING COUPLING changing of hydraulic attachments and accessories is quick and easy because individual fluid-carrying lines may be disconnected without loss of fluid and reconnected without inclusion of air. It is the only self-sealing coupling that mates with the Aeroquip Breakaway.

THE AEROQUIP BREAKAWAY COUPLING disconnects automatically when the implement accidentally breaks away from the tractor preventing breakage of hose lines and resulting loss of hydraulic fluid. With the Breakaway, pressure and return lines between tractor and implement may be connected and disconnected instantly. Each part of the Aeroquip Breakaway is replaceable.

Your customers can buy Aeroquip replacements through farm equipment dealers everywhere.

Aeroquip

REG. TRADE MARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

SALES OFFICES: Burbank, Calif. • Dayton, Ohio • Hagerstown, Md. • High Point, N. C. • Miami Springs, Fla. • Minneapolis, Minn. • Portland, Ore. • Van Wert, Ohio • Wichita, Kan.
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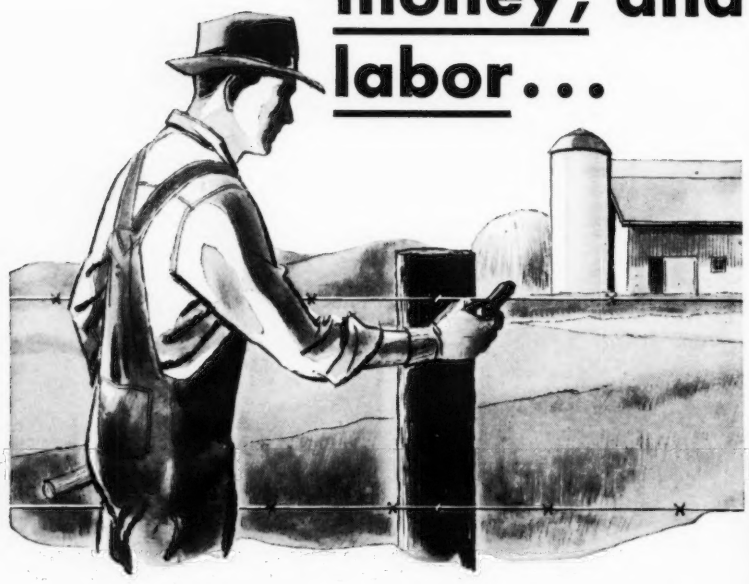
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Save the farmer time, money, and labor...



Recommend pressure-creosoted fence posts

● When you recommend pressure-creosoted fence posts, you're doing the farmer a *real* service. Since pressure-creosoted posts last 3 to 5 times longer than most types of untreated posts, repair and replacement costs are reduced to the barest minimum. Money, time, and labor, normally spent repairing or replacing deteriorated posts, can be devoted to more important jobs.

Pressure-creosoted fence posts are unharmed by repeated grass fires. Flaming stops, leaving only minor surface char, when the grass fire moves on.

For complete information about creosote, write to Koppers Co., Inc., Tar Products Division, Pittsburgh 19, Pennsylvania.

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Koppers Building

All Standard Specifications

KOPPERS **CREOSOTE**

The Performance-Proved Wood Preservative

New Products and Catalogs

(Continued from page 264)

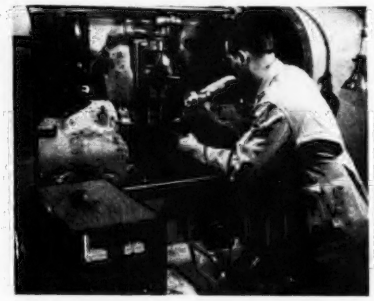
Device Aids Precision Bearings Production

The Timken Roller Bearing Co., Canton, Ohio, is using an instrument called the "vibratron" to locate abnormal vibrations in a machine, without the necessity of dismantling it. The device is making the job of maintaining accuracy in roller bearing manufacture a simpler and easier task.

This device, which is portable, is the industrial counterpart of the physician's stethoscope. It consists of a vibration pickup, a filtering probe, a stroboscopic lamp, and an electronic instrument that records frequency and amplitude of vibration.

The advantages of such a tool are readily apparent to the maintenance man, since detecting of out-of-balance parts, formerly a slow tedious task, has been greatly speeded up. Out-of-balance parts can now be detected while the machine is operating.

Timken tapered roller bearings are a highly accurate and precise product and go through many grinding operations. This



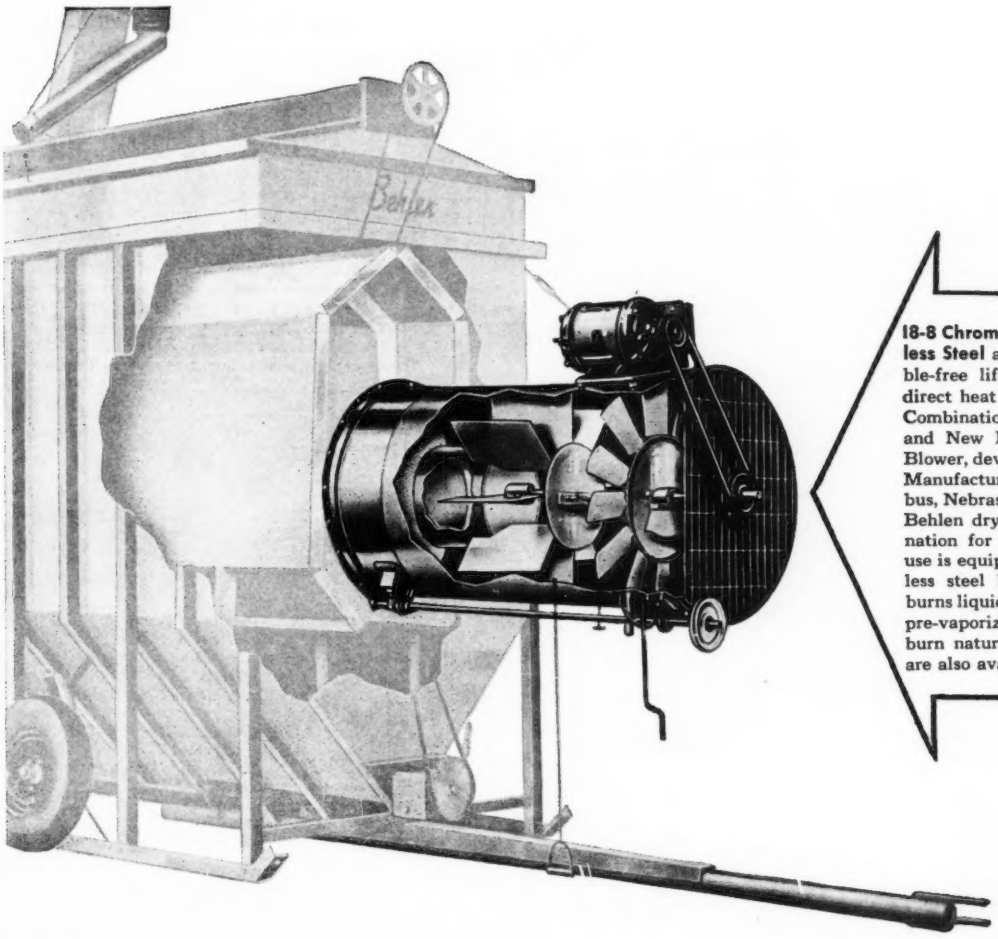
calls for many grinding machines and obviously their maintenance is of vital importance. By using the vibratron in its maintenance program, Timken has been able to maintain an average vibration level on its grinding machines to ninety millionths of an inch.

To correct an out-of-balance machine, it is completely shut down and a reading then taken with the vibratron. The probe of the instrument is placed on the spindle, bearing, or housing where it will be used for balancing later. This reading will show how much vibration is present in the floor of the building upon which the machine is set, also how much vibration is transferred to the machine being tested from other machines. This reading will represent the best obtainable after the machine in question is balanced.

With the pickup probe still in position, the various parts of the machine are started, one at a time, and the amplitude reading observed after each successive step. This indicates which parts of the machine give the most vibration. The part is double checked with the light which is triggered by the strongest vibration felt by the pickup probe. From this point on, it is simply a matter of balancing the unbalanced part by replacement or repair until the reading approaches as nearly as possible the reading taken with the machine shut off.

Manufacturing a product to such infinitesimal tolerances as tapered roller bearings requires extremely accurate machinery, and the new instrument used in detecting the slightest out-of-balance in machinery helps to consistently achieve such accuracy.

(Continued on page 268)



18-8 Chromium-Nickel Stainless Steel assures long, trouble-free life for the radial, direct heat type unit in this Combination Drying Tower and New Model "D" Heat Blower, developed by Behlen Manufacturing Co., Columbus, Nebraska. The complete Behlen drying tower combination for farm or elevator use is equipped with a stainless steel heat blower that burns liquid propane without pre-vaporization. Models to burn natural gas or fuel oil are also available.

Where use means abuse

...Chromium-Nickel Stainless Steel

Farm equipment usually gets rough treatment in operation and often deteriorates when not in use.

But here's a typical instance that shows how *stainless* provides advantages for manufacturer and user alike. It's a grain dryer with the combustion chamber made from Type 304 chromium-nickel stainless steel, primarily to assure resistance to the heat developed in operation and the corrosion which can occur during long periods of idleness.

Wherever use, or disuse, means abuse ... make vital parts from chromium-nickel stainless steels.

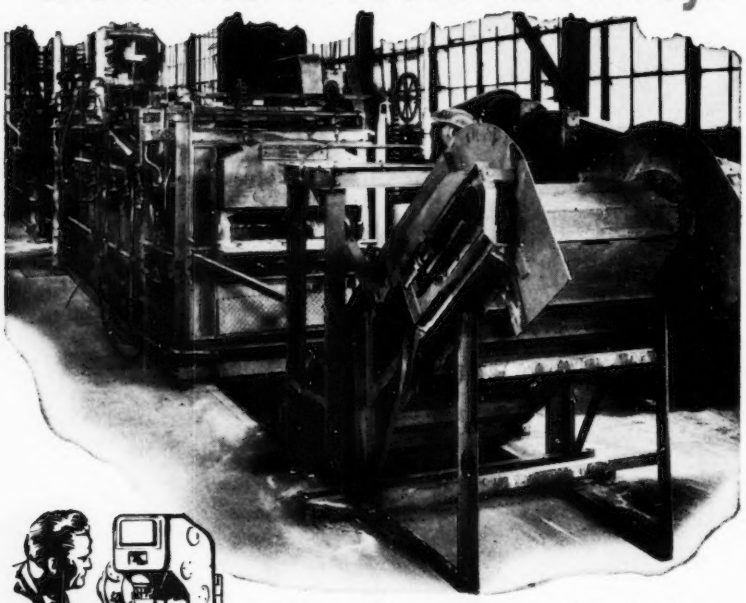
Stainless steels combine corrosion resistance and high mechanical properties. When cold-worked, they are strengthened and hardened ... easily developing a tensile strength in excess of 200,000 psi. Moreover, they are adaptable to many forming operations and can be readily welded. Distinguished not only by strength and resistance to oxidation at elevated temperatures, austenitic stainless steels retain their toughness and unusual strength at temperatures down to −300° F.

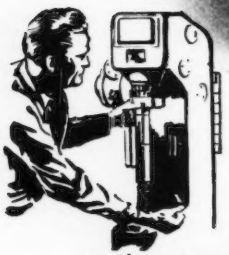
Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

New Unitcast Equipment Increases Process Accuracy!





Cuts Heat Treat Costs!

Installation and operation of continuous processing equipment in Heat Treating is another reason Unitcastings continue to maintain top quality with potentially *lower finishing costs!*

Practical use of this continuous method eliminates three of four variables common to multiple production heat treating. By eliminating *all* handling-in-process, labor costs are substantially reduced . . . and the human "margin of error" is removed. Concentrated processing of each casting is better accomplished by this method and heating, quenching and drawing time are accurately controlled. Subsequently the desired degree of hardness is held in closer range. Uniform machinability is the net result and your *final costs* are definitely *lower*. "Maintained accuracy" in Unitcastings is a provision of top quality!

Perhaps your finished costs are being held up by inaccuracy! Let Unitcastings solve this . . . and perhaps other problems, too. Write or call today for estimates and suggestions . . . no obligation!

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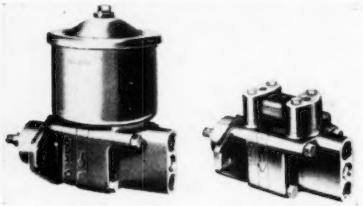
Unitcast QUALITY STEEL CASTINGS

New Products and Catalogs

(Continued from page 266)

Hydraulic Steering Package

Vickers, Inc., 1516 Oakman Blvd., Detroit 32, Mich., has announced general production of two new pump series for hydraulic steering systems—Series VT16 consisting of a Vickers vane-type hydraulic pump, flow control and overload relief valves and integral oil reservoir, and series VT17 comprising identical pump and valve units without the reservoir and designed for installations where a separate tank is preferred. The VT16 power package is designed for use with a hydraulic steering booster to form a complete power-steering system with simple

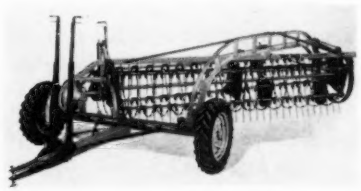


installation. The unit needs only to be bolted on, coupled to the engine (usually by belts), and two hydraulic connections made to the booster. Overload protection is built in. Other features of the unit include long life, no-load starting and automatic maintenance of optimum running clearance for continued high efficiency through use of Vickers hydraulic balance design and vane pump construction.

New Side Rake and Tedder

New Idea Farm Equipment Co., Coldwater, Ohio, announces two new side rakes and tedders, a high-wheel and low-wheel model. While retaining features of earlier models, the new rakes include these improvements: control levers to raise and lower the reel are within easy reach from the tractor seat. Caster-wheel spindle housings are larger, and gears, bushings, braces and bearings provide longer wearing qualities.

In re-engineering these rakes provision was made for a slight twist in the four-bar spiral reel which allows the teeth to contact



the hay one at a time, turning the tender leaves of the hay in and the tough stems out for even curing. The counter-balanced, non-bobbing reel yields to obstructions at either end and returns immediately to position without bobbin, skipping or weaving, thereby saving teeth and permitting faster operation on rough ground. Fifty-six double-curved teeth build fluffy windrows and eight double-straight teeth allow easy splitting of the swath.

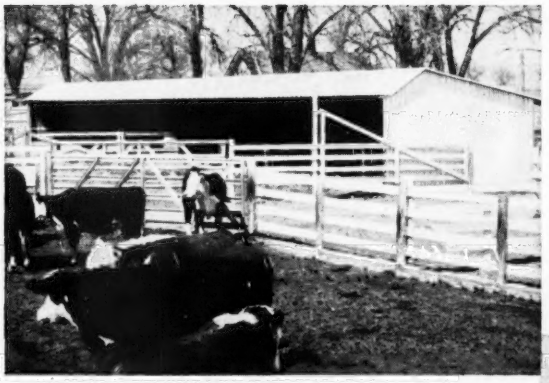
The bridge-trussed arch is high enough to permit raking under all conditions, and it prevents reel sag. The rakes are designed to handle a 7-ft swath easily but can handle smaller swaths or turn windrows equally well.

(Continued on page 270)

Left, above, one of four 10,000-bird hen houses of Lula Feed & Poultry Co., Gainesville, Ga., roofed in 1949 with Reynolds *Lifetime* Aluminum 5-V Crimp. Below—a typical range shelter.

More Profit Per Pound of Feed with

REYNOLDS *Lifetime* ALUMINUM



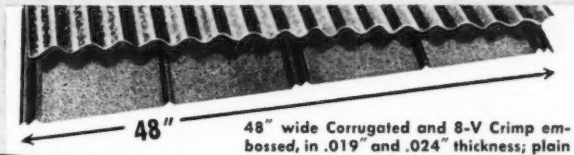
"Low maintenance, insulation and appearance" are the reasons Everly W. Austin gives for using Reynolds *Lifetime* Aluminum on his South Longmont, Colo., farm. Pole barn shown, for beef cattle, is **"very satisfactory,"** says Mr. Austin.

"More broiler meat per pound of feed," says Larry W. Wolfe, president of Lula Feed and Poultry Co., Gainesville, Ga. **"Egg production, too, is higher under aluminum roofing than under any other material, because it keeps down inside temperature."**

That profit-making heat reflection of aluminum works year-round...keeps buildings warmer in winter, too. Works for *all* livestock...hogs, dairy cows, beef cattle. Steps up profits while it lowers operating cost. No painting!

Initial cost is now lower than ever, with Reynolds' new 48" wide sheets. See your dealer! **Reynolds Metals Company,** Building Products Division, Louisville 1, Kentucky.

New 48-Inch Widths Save On Labor and Material!



48" wide Corrugated and 8-V Crimp embossed, in .019" and .024" thickness; plain Corrugated in .019". Also standard widths.

USE THESE PLANS FOR LOW-COST, LABOR-SAVING BUILDINGS... PREPARED BY REYNOLDS FARM INSTITUTE.

Check coupon for plans you want...prices include detailed drawings, erection instructions and material lists. Or check coupon for FREE literature.

FARM INSTITUTE

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Reynolds Farm Institute, P. O. Box 1800, Louisville 1, Ky.

I enclose $_____ for plans of buildings checked.

☐ Please send FREE literature on buildings checked.

☐ 52' x 60' Pole Barn	$1.00	☐ 1,500-bird Pole Laying House (expandible)	$1.00
☐ 26' x 60' Machinery Center	1.00	☐ 10,000-bird Pole Broiler House (expandible)	1.00
☐ 30' x 32' Corn-Crib	.50	☐ 14' x 20' Hog or Sheep Shelter	.25
☐ 8' x 10' Portable Range Shelter	.25	☐ 16' x 20' Cattle Shelter	.25
☐ 26' x 60' Pole Cattle Shed	1.00	☐ 12' x 20' Sectional 4-Sow Farrowing House	.25

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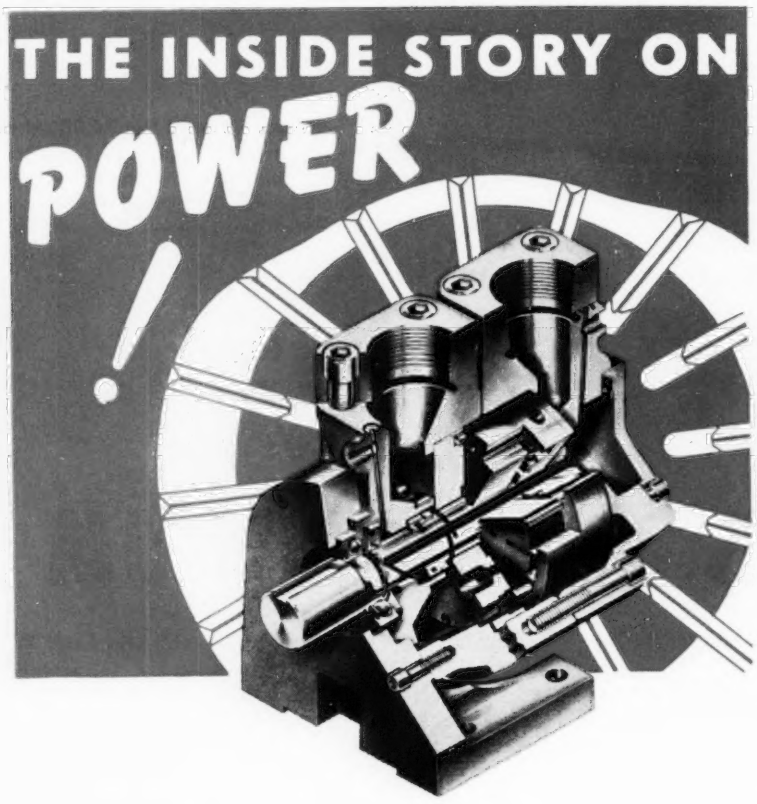
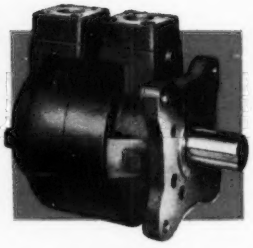
CITY _____ STATE _____



the ALL Way Balanced Dual-Vane

DUDCO
HYDRAULIC PUMP



Featuring starting torques higher than running torques, DUDCO has long been recognized as the most efficient Fluid Motor in the field. Standard models from 180 lb. in. to 14,400 lb. in.

One look at the inside of a DUDCO Pump tells the story of efficiency through *fully* balanced construction. Note how, at all times, the Dual-Vanes provide a *double* barrier to slippage and lost power. These DUDCO Vanes are individually balanced to closely follow the cam ring contour without wear-producing thrust . . . their unique displacement action provides an extra 15% to 20% added volume.

Smooth, non-pulsating DUDCO power, delivering 2000 psi for continuous operation, frequently doubles the capacity of less efficient hydraulic circuits. Standard models from 3 gpm to 120 gpm.

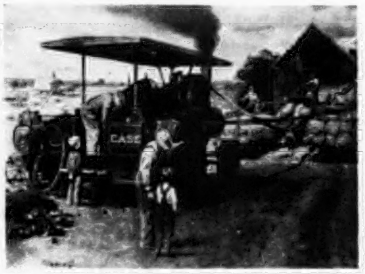
DUDCO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1707 EAST NINE MILE ROAD • HAZEL PARK • MICH.

New Products and Catalogs

(Continued from page 268)

Steam Threshing Picture

Prompted by the wide-spread interest in old steam engines such as the old-time threshermen used, J. I. Case Co., Racine, Wis., commissioned a talented young artist, Medcalf, to reproduce a typical steam threshing scene which is used on the company's 1954 business calendar. Reprints of the calendar picture, suitable for framing, have



been made available at a nominal cost to cover packing and mailing. Readers interested may obtain them direct from the company. Color prints in a mailing tube are 25c each, or mounted on a wide mat ready for framing, 50c each.

The editor can testify to the exquisite beauty and genuine atmosphere of this old-time threshing scene and is proud to have one on the wall in his office.

Engine with Electric Start

Kohler Co., Kohler, Wis., announces that its K660, 4-cycle, heavy-duty engine announced some months ago is now available with electric start. The engine is equipped with a 6-v electric starter and generator, ig-

nition switch and starter button. It carries a number of standard features including an impulse-coupling magneto, a silencer-type muffler, valve rotators, automotive diaphragm-type fuel pump, oil-bath cleaner and an oil-pressure gauge.

Bulletin on Semi-Pneumatic Tires

The Ohio Rubber Co., Willoughby, Ohio, will send on request to interested readers a special publication on its "Soil King" line of semi-pneumatic press and gauge-wheel tires engineered and manufactured especially for agricultural service. This piece of literature describes the company's three types of tires, namely gauge wheel, press wheel and seed press—all semi-pneumatic, flexible-rubber tires with hollow centers.

Chain Bulletin

Chain Belt Co., Milwaukee 1, Wis., will send on request to interested readers a copy of its new bulletin describing Rex Z-Metal chain which is made of special heat-treated alloyed ferrous metal. The bulletin describes the many applications of the product and reports laboratory and field tests to verify the claims for the metal. Requests for copies of the bulletin should specify Bulletin 53-56.

New Self-Propelled Combine

J. I. Case Co., Racine, Wis., announces a new self-propelled combine, the "120," with power steering and hydraulic control of the variable-speed traction drive. The power steering uses a booster cylinder and control valve so that when hydraulic power is brought into action short turns are facilitated even in soft soil. The hydraulic speed control operated by a rocker pedal or hand

lever acts on the V-belt variable-speed drive and provides a wide range of speeds in each of three forward gears. Hydraulic header control, operated from the steering post, adjusts the cutting height.

Headers with three cutting widths are offered—12 feet for average grain conditions, 15 feet for dry-land or other light-crop areas, and a 10-foot size for soybeans. Headers are quick-detachable, for full access to the cylinder and for transport by truck.

A new comfort seat, with torsional rubber suspension that absorbs shocks and vibration, is located up and forward where it gives a good view of reel, cutterbar and header.

Rotary Cutter

Ford Motor Co., Tractor and Implement Div., Birmingham, Mich., announces that it has added to its farm machinery line a tractor-powered rotary cutter designed for use in disposing of corn and cotton stalks and other crop residues difficult to plow under without chopping. It can also be used to clip pastures, control certain noxious weeds, cut small brush and tree sprouts, etc.

This 653-lb machine is attached directly to the Ford tractor and is lowered and lifted hydraulically. The hardened steel alloy blades of the cutter are driven by the tractor power take-off and a gauge wheel with puncture-proof tire provides a cutting height range of from 2 to 10 in. All universal joints are shielded for safety. A rear adjustable floating shield and a front shield protect people working near the implement, as well as the operator and tractor, from flying debris.

The TERRALOAD'R, built by American Tractor Corp'n., Churubusco, Ind., features HYDRECO Oil Power which contributes to its great versatility, ease and speed of operation as Loader, Dozer and Excavator.

The famous Four-Bolt design HYDRECO Pump which locates the assembly bolts in the area of greatest internal pressure. 3 to 130 gpm for working pressures to 1500 psi at speeds to 2000 rpm.

Yes, the TERRALOAD'R is

Oil Powered by a

HYDRECO

HYDRAULIC PUMP

No glass-house weakling is the TERRALOAD'R. Out where the going is rough ...moving stones, gravel, sand or dirt... day after day...rain or shine...There you find the TERRALOAD'R! And the source of its hydraulic power is a sturdy, dependable HYDRECO Four-Bolt Pump delivering 7 gpm at 1000 psi.

HYDRECO Hydraulic components are original equipment on more and more hard working vehicles in the construction, agricultural and earth moving fields, because they perform up to the expectations of design engineer and operator alike.

Write for complete information on HYDRECO Pumps, Motors, Valves, and Cylinders for your hydraulic circuits.

HYDRECO Gear Type Motors featuring the easily serviced Four-Bolt design . . . fully reversible . . . delivering up to 52 hp.

HYDRECO Hollow Plunger Valves with capacities of 5 to 80 gpm . . . 1 to 5 single or double acting plungers . . . covering virtually any application.

HYDRECO Single Acting, Double Acting, and Telescopic Cylinders as well as those of special design.

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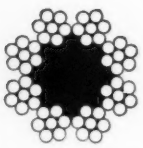
wire rope and fittings

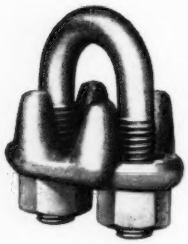
ENGINEERED FOR SAFETY

YOU can fill all farm machinery requirements for wire rope and rope fittings from Upson-Walton —with products especially engineered for safety. Complete catalogs of wire rope and rope fittings available free on request.



8 x 7 farm machinery rope

Upson-Walton wire rope is available in all standard constructions, and ones particularly suited to farm machinery use. We welcome an opportunity to work with you in selecting the wire rope for your equipment. Our long experience in this field means better service for you.



CLIPS

Galvanized drop forged steel (as shown) — Malleable iron enameled or galvanized—For rope diameters: ¼" to 1½".

TURNBUCKLES

Drop forged steel, weldless—self-colored or hot galvanized—with and without stubs, hook, eye, or jaw end fittings—Thread diameters ⅜" to 2".

SHACKLES

Drop forged steel—enameled or hot galvanized—Chain or anchor types — Screw pin or round pin—From ¼" to 2".

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Hot galvanized wrought steel — regular and heavy weights — For rope diameters from 3/16" to 2".

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NEW BULLETINS

Deutsche Ackerschlepper (German tractor field book). Special issue of the *Landtechnik* Nr. 21/53 124 pages, 74 pictures, A4, price DM 2.— The bulletin covers all German tractors with technical data, as of the end of 1953.

Some Factors Affecting the Quality of Frozen Foods. Pennsylvania Agricultural Experiment Station (State College) Bulletin 565 (April, 1953). A brief technical report covering materials and methods of freezing, engineering studies, bacteriological studies, biochemical studies, and palatability studies.

Freezing Rates of Foods and Storage Temperatures in Vertical Cabinets, by John E. Nicholas. Pennsylvania Agricultural Experiment Station (State College) Bulletin 572 (October, 1953). Reports briefly on experiments dealing with freezing methods and rates, storage temperatures, and experimental techniques.

Seeding in Permanent Pasture for Supplementary Winter Grazing, by Richard F. Dudley and Louis N. Wise. Mississippi Agricultural Experiment Station (State College) Bulletin 505 (October, 1953). Reports results of two years experiments indicating that oats, wheat, ryegrass, and other supplementary winter growing forage crops may be successfully drilled in permanent pasture sod without conventional seedbed preparation. Winter pasture is provided with minimum reduction of summer pasture yield, and an increase in total annual forage production per acre. Results were better than with conventional seedbed preparation or with surface seeding with little or no preparation. Specific practice recommendations are offered.

Sprinkler Irrigation, by H. C. Schwalen, K. R. Frost, and W. W. Hinz. Arizona Agricultural Experiment Station (Tucson) Bulletin 250 (October 1953). This summarizes current information on the practice as carried out under Arizona conditions.

Organization of the Looseleaf Tobacco Auction Market, by Carl M. Clark and Wilmer Browning. Kentucky Agricultural Experiment Station (Lexington) Bulletin 599 (June 1953). Includes information on warehouse structure, layout, operating facilities, and handling and storage operations.

Serving Homes Heated with Electricity. REA Bulletin 142-5 (August 1953). (Requests for individual copies may be addressed to J. P. Schaenzer, operations division, REA, U.S. Department of Agriculture, Washington 25, D.C.

This reports a study by the REA in cooperation with the Warren Rural Electric Cooperative Corp., at Bowling Green, Ky. It covers energy consumption; demand, diversity, and load factor; purchased power requirements and cost; system investment, annual expenditures, and revenue. It considers future possibilities, based on 24 house heating installations currently in use in the area served. They represent an average connected load of 15 kw per house which is estimated as 30 percent above the minimum capacity required for the design outdoor low of zero Fahrenheit. Records of 16 consumers showed an average annual energy consumption of over 14,000 kwh per house for house heating alone, which was several times the consumption in those houses for all other purposes combined.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Bennett, Francis W.—Sales trainee, Caterpillar Tractor Co. (Mail) 622 Fon du Lac Drive, East Peoria, Ill.

Bhavnani, Prem H.—Assistant engineer, Government of India. (Mail) Central Tractor Units, Bhilsa (M.B.), India

Boyce, Erwin K. — Design engineer, The Oliver Corp., Springfield, Ohio. (Mail) 1825 Fairway Drive

Buske, Paul, Jr. — Manager, Sunset Valley Farms, Long Valley, N. J.

Cantoni, Elvin—Sales engineer, Byron Jackson Co., 719 K St., Room 323, Sacramento 14, Calif.

Cornish, Harrison C. — Farm service representative, The Connecticut Light and Power Co., 1270 Main St., Willimantic, Conn.

Davis, James O.—Sales engineer, Hilbe Engineering, Inc., 130 S. Grand Ave., Glendora, Calif.

Doty, John C.—Field superintendent, Doty and Doerner Nurseries, Inc., 6691 SW Capitol Highway, Portland 19, Ore.

Edwards, James R. — District rural service engineer, Alabama Power Co., P.O. Box 329, Sylacauga, Ala.

Enlow, Robert E.—Associate editor, "Capper's Farmer," 912 Kansas Ave., Topeka, Kans.

Ghahremani, A. Moayed — Irrigation engineer and manager of pumps department, Farmers Mercantile Co., Watsonville, Calif. (Mail) PO Box 186

Gonzalez, Ovidio — Extension agricultural engineer, Agricultural Extension Service, PO Box 607, Rio Piedras, Puerto Rico

Gordon, Yoram—Hydraulic engineer, U.S. Navy, San Bruno, Calif. (Mail) 1641 Allston Way

Gray, Thomas L. — Agricultural engineer, (SCS), USDA. (Mail) Box 159B, RR 3, Waco, Tex.

Guterba, Floyd W.—Instructor, Ohio State University, Columbus, Ohio. (Mail) 396 Wyandotte Ave.

Helms, John E.—Student in agricultural engineering division, California State Polytechnic College, San Luis Obispo, Calif. (Mail) Box 1244

Hiett, William G.—Development representative in agricultural extension section, U.S. Steel Corp., 525 William Penn Place, Pittsburgh, Pa.

Kline, Paul C. — Irrigation engineer and salesman, Kline Implement Co., Mendon, Mich. (Mail) RFD 1

Kohlman, Emery H.—Assistant zone manager, International Harvester Co. (Mail) Oak Harbor, Ohio

Kroutil, Wayne F. — Junior engineer, John Deere Harvester Works, East Moline, Ill. (Mail) 726 23rd Ave.

Lange, William J. — Engineering assistant, East Bay Municipal Utility District, Lodi, Calif. (Mail) PO Box 61

Lawrence, George A.—Conservation engineer, (SCS), USDA. (Mail) 1896 S. 1800 East St., Salt Lake City 5, Utah

Nelson, Edwin E.—2nd Lt., Army Transportation Corps. (Mail) 1228 Cottage St., Ashland, Ohio

Patel, Shantibhai M. — Student in agricultural engineering department, King's College, Newcastle/Tyne, England

Pronio, Harry A.—General manager, Roper Mfg. Co., Zanesville, Ohio. (Mail) PO Box 843

Rumely, E. S.—Manager of product planning and programming office, tractor and implement division, Ford Motor Co., Birmingham, Mich. (Mail) 678 Covington Rd.

Satterwhite, Leron E.—Graduate student, A. and M. College of Texas, College Station, Tex. (Mail) Project House Apt. 12-A

Sayer, James A. — Electrification advisor, Northern Electric Cooperative Assn., Box 13, Virginia, Minn.

Schultz, Thomas W.—Product engineer, Gar Wood Industries, Inc., Findlay, Ohio

Shrivastwa, Vaidyanath P. — Postgraduate student in agricultural engineering, King's College, Newcastle-upon-Tyne 1, England

Sittler, Robert R.—Production engineer, McMillen Feed Mills, Marion, Ohio (Mail) 143½ Hill St.

Smith, Hiram P. — Chief engineer, International Harvester Co., PO Box 1729, Stockton, Calif.

Smith, Phillip B. — General agriculturist, Great Western Sugar Co., Terminal Annex Box 5308, Denver, Colo.

Spore, Robert G. — Electrification adviser, Custer Public Power District, Broken Bow, Nebr.

Srivastava, Sidh N.—Student in agricultural engineering department, King's College, University of Durham, Newcastle/Tyne 1, England

Thompson, Marvin D.—Instructor in agricultural engineering department, Wisconsin State College, River Falls, Wis.

Walters, George E.—Agricultural engineer, Great Western Sugar Co., Box 5308, Terminal Annex, Denver 17, Colo.

Wenzel, Philip D.—Design engineer, J. I. Case Co., PO Box 1848, Stockton, Calif.

Whitlock, Walter W.—Director of research

KOHLER ENGINES

4-CYCLE
AIR-COOLED

K90

K160

K90 3.6 H.P.
K160 6.6 H.P.
K330 12.0 H.P.
K660 26.8 H.P.

Kohler Engines are engineered and manufactured to the high standards which have made the Kohler mark known for quality the world over.

Power for garden tractors, pumps, sprayers, snow removal equipment, grain elevators, hoists, portable saws, concrete mixers, compressors, industrial lift trucks.

Write for information

K330

K660

Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

and quality control, Illinois Farm Supply Co., 100 E. Ohio St., Chicago 11, Ill.

Transfer of Membership Grade

Flikke, Arnold M. — Assistant professor in agricultural engineering department, University of Minnesota, St. Paul, Minn. (Associate Member to Member)

Gilchrist, E. D.—Supervisor of tile drainage, New Brunswick Department of Agriculture, Fredericton, N. B., Canada. (Affiliate to Member)

Peterson, Glenn M.—Agricultural engineer, The Oliver Corp. (Mail) 179 N. Lombard Ave., Oak Park, Ill. (Associate Member to Member)

Williams, George E.—Agricultural engineer. (Mail) c/o Dr. A. R. Younie, RR 1, St. Catharines, Ont., Canada. (Affiliate to Associate Member)

New British Bulletins

Following is a list of publications recently furnished with the compliments of the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England. Some will be of interest to agricultural engineers in other parts of the world. Copies may be ordered from the publication sales department of the Institute at the above address. Where a price is stated on the bulletin, it is shown (in parentheses) following the designation.

Report on Test of David Brown 30C(V.O.) Tractor—BS/NIAE/51/2

Report on Test of David Brown 30TD Tractor—BS/NIAE/52/4, (6d)

Report on Test of Fowler "Challenger 3" Diesel Crawler Tractor—BS/NIAE/52/6, (6d)

Report on Test of David Brown 30D Tractor—BS/NIAE/53/2, (6d)

Report on Test of Field Marshall Series 3A Diesel Tractor—BS/NIAE/53/3, (6d)

Report on Test of David Brown 30C (Petrol) Tractor—BS/NIAE/53/6, (6d)

Report on Test of Fowler Mark VFA Diesel Crawler Tractor—BS/NIAE/53/8, (6d)

Report of Test on Continental CD70 Diesel Tracklaying Tractor — BS/NIAE/53/9, (6d)

Report on Test of New County Crawler Tractor with Fordson Diesel Engine—BS/NIAE/53/10, (6d)

Report on Test of Fewster Dual Purpose (Grass and Grain) Drier—No. 71

Report on Test of Humberside Extension Wheels Fitted to New Fordson Major Tractor—No. 72

Report on Test of David Brown 30TD Tractor—No. 73

Report on Test of David Brown Cropmaster (V.O.) Tractor—No. 74

Report on Test of David Brown (V.O.) Tractor—No. 75

Report on Test of The British Anzani Cultivator—No. 76

Report on Test of The British Anzani General Purpose Plough—No. 77

Report on Test of Field-Marshall Series 3A Diesel Tractor—No. 78

Report on Test of The Cooch Vegetable Washing Machine—No. 79

Report on Test of David Brown 30D Tractor—No. 80

Report on Test of The Howard "Rotavator Gem" Series IV Model—No. 81

Report on Test of The Quicktest Grain Moisture Tester—No. 83

Report on Test of Orchard Mist Spray Attachment—No. 85

The Development of a Universal Vegetable Washing Machine of Medium Output. II. Continuous belt type, incorporating a pre-wetting section, C.S. 18 (Part II)

Report No. 23—Soil Capping by Water Drops.

Report No. 27—A Spray Deposit Analyser.

Report No. 29—An Elevator-Loader for the Bulk Handling of Potatoes into Permanent Stores

Report No. 30—Design of a Precision Plot Irrigator

Report No. 31—A Study of the Methods of Measuring Small Spray Drops

Report No. 32—Preparation and Calibration of Glass Slides for Sampling Sprays.

Report No. 33—The Modified Brown-Duvel Moisture Test

Report No. 34—The Use of Polythene Film Bags for Grain Samples

Technical Memorandum No. 84—The Measurement of Solar Energy in an Experimental Glasshouse

Technical Memorandum No. 86—The Dependence of the Water Requirements of Glasshouse Crops Upon the Total Incoming Solar Radiation

Technical Memorandum No. 96 — A Soil Adhesion Meter.

Technical Memorandum No. 97—A Simple Method of Obtaining Constant Flow from a Gravity Tank

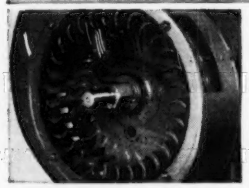
Technical Memorandum No. 98 — Experimental Outdoor Grain Storage Silos (Interim Report, October 1952—April 1953)

Abstracts from World Literature Nos 1-241—Agricultural and Horticultural Engineering Abstracts—Vol. IV, 1953—No. 1

Abstracts from World Literature—Nos. 242-501—Agricultural and Horticultural Engineering Abstracts—Vol. IV, 1953—No. 2

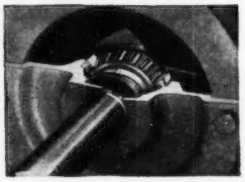
Agricultural and Horticultural Engineering Abstracts—Index Volume IV, 1953.

WISCONSIN
HEAVY-DUTY Air-Cooled ENGINE
Performance Features



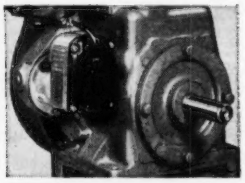
TROUBLE-FREE, ALL WEATHER AIR-COOLING . . .

No farm machine is any better than the Power that drives it. And efficient cooling, under all operating conditions, is one of the first essentials to dependable power! A large capacity fan, cast in the flywheel of every Wisconsin Engine, provides trouble-free cooling, even in the most extreme temperatures.



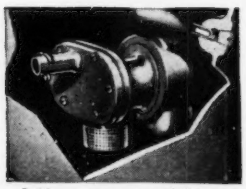
TAPERED ROLLER BEARINGS AT *BOTH ENDS* OF CRANKSHAFT . . .

These self-cleaning, file-hard bearings take up all load thrusts, permitting the use of either chain-, belt- or gear-drive direct from the extended crankshaft, without fear of damaging main or connecting rod bearings. This does away with the need for an outboard bearing.



HIGH TENSION, ROTARY TYPE OUTSIDE MAGNETO . . .

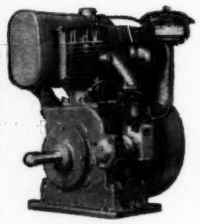
Positive gear drive direct from camshaft assures steady, uniform ignition at all times. The complete unit is conveniently mounted on the OUTSIDE of the engine for easy accessibility. Weather-sealed against moisture and dust. Equipped with Impulse Coupling for quicker, easier starting at all seasons.



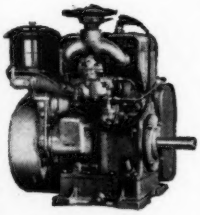
POSITIVE, PUMP-CIRCULATED LUBRICATION . . .

All single cylinder models (with exception of Model AEN) have pump-circulated level splash system. Model AEN and multi-cylinder models pump an individual oil stream to each connecting rod. Other parts are lubricated by oil spray, assuring complete and thorough lubrication for smooth-running and long engine life.

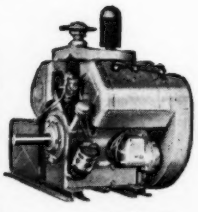
• *These are some of the reasons why it pays to specify "WISCONSIN AIR-COOLED ENGINES" as standard Power Components.*



• Single Cylinder 6 to 9 hp.



• 2-cylinder 7 to 15 hp.



• 4-cylinder V-type 15 to 36 hp.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

A 7860-½-1

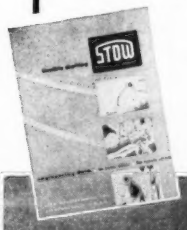
Dependable performance for aircraft sprayers . . . with

STOW flexible shafting!

It's important in crop spraying to get thorough coverage of the crop. That calls for reliable equipment like the Aero Mist Master which depends on STOW flexible shafting to transmit power from the accessory gear box to the pump which delivers the insecticide to the spray nozzles beneath the wing.

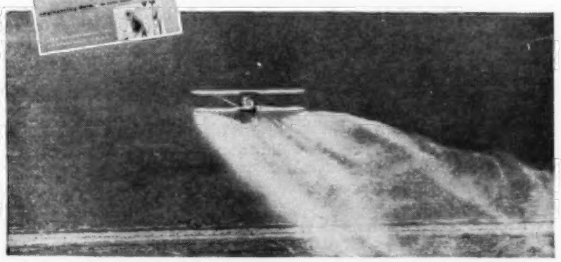
According to Mabry I. Anderson, of Mississippi Valley Aircraft Service, manufacturers of the Aero Mist Spray System, "Your shafts have never failed—even though they've already given us thousands of hours of *trouble free* service".

Consider STOW flexible shafting for your next Power Drive or Remote Control application. Our engineering department will be happy to work with you. No obligation, of course.



◀ ***Write today*** for your free copy of Bulletin 525 containing complete engineering data on STOW flexible shafting.

See us in SWEET'S CATALOG



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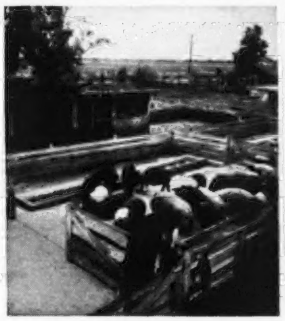

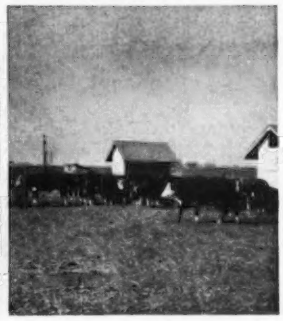

Help Farmers

pave the way to profits with CONCRETE

All over America agricultural engineers are proving to farmer-clients that paving with concrete pays. They are demonstrating that concrete-paved improvements such as those shown here soon pay for themselves—and continue to pay dividends for many years.

With such long-lasting, concrete-paved improvements farmers can forget the back-breaking chores of frequent filling and grading of unpaved barnyards, feed lots and floors. Concrete paving saves so much time that it's like having an extra hired hand.

Savings in manure alone often pay the cost of a barnyard or feed lot in a short time. Feed savings are substantial too. Besides, cattle and hogs make much faster gains when they're not using energy to fight mud.

Concrete improvements are moderate in first cost, require little or no maintenance, last a lifetime. That's ***low annual cost.***

Portland Cement Association field engineers will gladly help agricultural engineers on concrete farm improvement problems.

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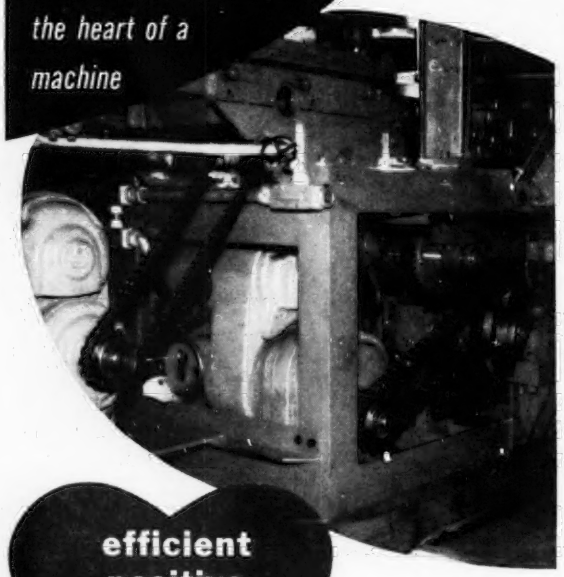

efficient positive dependable

Here's a *section* of special equipment that was built for conveying heavy loads in perfect time. In cooperation with Cullman engineers these roller chain drives were developed for use on a heavy duty, high speed conveyor.

If you too want roller chains that can take it – that can cut operating costs and give top performance, then take advantage of a Cullman roller chain drive tailored to your needs.

For full information or help on your power transmission problems write direct or contact the Cullman man in your area. He'll be glad to work with you. No obligation of course.

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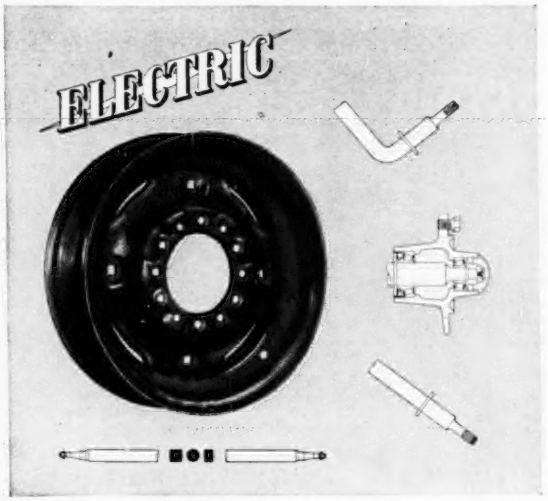

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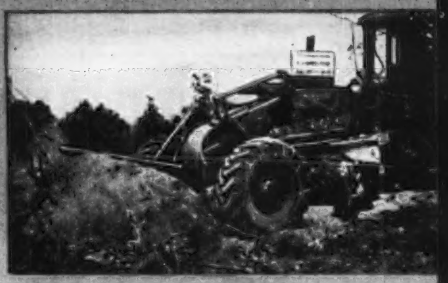
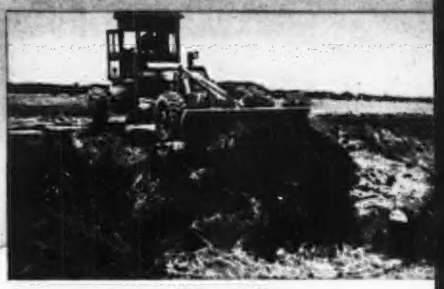


Clearing brush



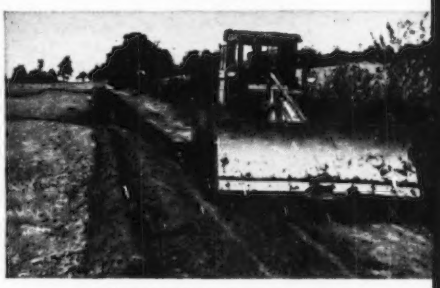
Filling gullies

An A-W Grader Can Make Your Plans COME TO LIFE

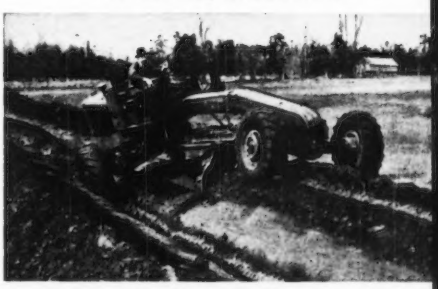
The task is great . . . the incentive tremendous . . . the goal can be reached if sights are set high!

But not with LITTLE plans. LITTLE plans, however good in themselves, will not get complete land-use patterns on the hundreds of thousands of farms and ranches that need them badly, until too late. LITTLE plans on individual farms will not solve the problems of watersheds, large and small.

With an inspiring record of cooperative achievement to their everlasting credit, landowners, technicians and educators can give America TOTAL CONSERVATION one of these years. But not with LITTLE plans.



Constructing terrace outlets



Cutting ditches

Spreading spoil banks

Shaping waterways

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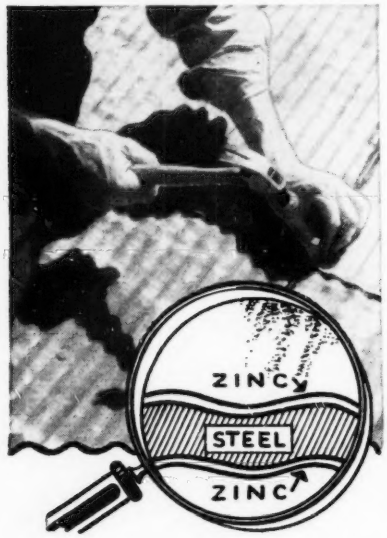
GALVANIZED ROOFING



Value in galvanized roofing is measured in rust-free service—and rust-free service depends on the weight or thickness of the zinc coating.

This weight or thickness of zinc coating cannot be determined by looking at a galvanized sheet.

Insist on *grade-marked* galvanized roofing and know what you are getting. A small difference in the weight of coating means a large difference in the length of service.

It is thrifty to purchase metal roofing that is *grade-marked* to show the weight of the zinc coating.

Select the proper grade for the proper use—and for long rust-free service life and lowest per-year cost . . .

Specify a heavy-coated sheet such as "Seal of Quality," the SUPER SHEET for SUPER SERVICE

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FREE . . . INSTRUCTION MANUALS

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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — 1953—OCTOBER—O-348-534, 344-536, 361-537. NOVEMBER—O-341-538, 384-540. DECEMBER—O-454-544, 465-545, 471-546, 479-547. 1954—JANUARY—O-488-549, 491-550, 494-551, 508-552. FEBRUARY—O-19-602. MARCH — O-65-603, 66-604, 67-605, 68-606, 73-607, 62-608, 74-609, 75-610, 75-611.

POSITIONS WANTED — 1953—SEPTEMBER—W-306-53, 339-56. OCTOBER—W-357-58. NOVEMBER—W-368-63, 369-66, 404-74, 426-75. DECEMBER—W-395-76, 410-77, 431-78, 396-79, 405-80, 425-81, 420-82, 443-83, 423-84, 453-85, 451-87. 1954 — JANUARY — W-456-88, 487-89, 490-90, 484-91. FEBRUARY—W-5-102, 20-103, 24-105, 25-106, 45-107, 46-108. MARCH—W-16-110, 56-112, 54-113, 29-114, 70-115, 37-116, 64-117, 78-118.

NEW POSITIONS OPEN

GRADUATE RESEARCH ASSISTANT in irrigation, farm power and machinery, rural electrification, or structures in an eastern state university. BS deg in agricultural engineering or equivalent, with B average or better. Experience desirable in field selected. Able to work with others. Half time on work toward MS deg, half on research for department. Opening effective July 1 or sooner. Salary $1200-1500 for 12 mo. O-90-613

AGRICULTURAL ENGINEER, field representative for trade association to handle educational and promotional work in farm structures, through colleges, extension specialists, 4-H Clubs, vocational agriculture leaders, farm managers, exhibits, in Midwest. Considerable travel necessary. Age 25-35. BS deg, preferably with major in farm structures. Farm background and sales or promotional experience in farm field desirable. Usual personal qualifications for contact work. Good opportunity for advancement. Salary $375 per mo or higher to start, depending on experience. O-98-614

ENGINEER AND TRAINEE (one each) for implement design and development with a leading manufacturer in Midwest. Steady position. BS deg or higher in agricultural or mechanical engineering. Implement engineering experience desirable. Not subject to military service. Salary open. O-106-615

SALES ENGINEERS (2) to contact dealers and customers for irrigation equipment, in the Midwest. Also office engineer for irrigation system design and layout work. Travel required for sales engineers. Agricultural engineering background. Usual personal qualifications for sales engineering. Experience in selling irrigation equipment or centrifugal pumps desirable. Good opportunity for advancement. Salary or commission, open. O-102-616

AGRICULTURAL ENGINEER for design, development and test work on agricultural implements with established special line manufacturer in Midwest. Age 25-35. BS deg in agricultural engineering. Experience 3 to 5 yr in design, development and testing of agricultural implements. Must have initiative, dependability, power of analysis, good judgment. Good opportunity for advancement. Salary open. O-116-617

DESIGN ENGINEERS, senior layout draftsmen, layout draftsmen, detail draftsmen, with established broad line farm equipment manufacturer in Midwest. Excellent career possibilities for qualified men genuinely interested in design and development of farm machinery. Age under 45. Graduates in agricultural or mechanical engineering required for design engineers and senior layout draftsman. Also 8 yr or more experience in gear and transmission design, internal combustion engine design, and design of tractors and other farm equipment particularly desired. Layout draftsmen, 4 yr experience. Must be able to prepare basic layouts of machines and components with minimum supervision and handle necessary calculations. Salary open. O-134-618

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development or research in power and machinery with manufacturer, processor or distributor. Any location in U.S.A., or South America. Married. Age 27. No disability. BS deg in agricultural engineering, 1952, University of Arkansas. Office engineering 18 mo. Maintenance engineering 7½ mo. Quonset warehouse construction 6 mo (military service). Farm background. War enlisted service in Navy, 38 mo. Willing to travel occasionally. Available on 15 days notice. Salary open. W-86-119

AGRICULTURAL ENGINEER for extension, teaching, service, writing, or management in power and machinery, farm structures, or rural electric field, with industry or public service. Anywhere in U.S.A. Married. Age 36. No disability. BS deg in agricultural education, 1941, MS deg in agricultural engineering, specializing in rural electrification, 1946, Michigan State College. Teaching vocational agriculture and farm shop, 13 yr. Superintendent of schools, 3 yr. Farm background. Owned and operated small farm 2 yr. Worked for construction companies. Built own home. Secretary of county fair. Available July 1, or sooner. Salary $5000. W-84-120

AGRICULTURAL ENGINEER for development, research, teaching, or writing in farm structures or product processing field, with college, manufacturer or processor, anywhere in U.S.A. Married. Age 30. No disability. BS deg in agricultural engineering, 1951, Purdue University. MS deg in agricultural engineering expected in May, 1954, Purdue University. Farm background. Farm operation, 3 yr. Teaching and research in agricultural processing, 3 yr. Commissioned service in Air Force 2½ yr. Available July 1. Salary open. W-101-121

AGRICULTURAL ENGINEER for sales, service, writing, or management in power and machinery or farm structures with industry, anywhere in U.S.A., willing to travel. Single. Age 24. Vision corrected by glasses. BS deg in agricultural engineering, 1952, Kansas State College. Farm background. Postwar commissioned service in Air Force 2 yr. Project engineer officer on aircraft droppable store suspension, release, and ejection devices. Available August 1. Salary $4800. W-96-122.

AGRICULTURAL ENGINEER for design, development or research in farm structures or product processing with industry in West, Midwest, or foreign location. Willing to travel occasionally. Married. Age 33. No disability. BS deg, 1949, Purdue University. Agricultural engineer with Farmers Home Administration, 4½ yr. Consulting work 6 mo. Bureau of Reclamation, one year. War enlisted service 4 yr, Air Force. Available now. Salary $5000. W-93-123

AGRICULTURAL WRITER and public relations specialist interested in new location, preferably with industry in metropolitan area. BS deg, 1929, Northwestern University. MA deg 1933, George Washington University. Certified candidate for PhD in economic history, Columbia University. Writing and public relations experience 23 yr. War commissioned service in Navy 17 mo. Married. Age 45. No disability. Available on 2 weeks' notice. Salary $10,000. W-109-124

AGRICULTURAL ENGINEER for design, development, or management in power and machinery, product processing, or crop production, with industry or federal agency, in Far East, Europe, Hawaii, Cuba, or South, West, or East in U.S.A. Married. Age 30. No disability. BS deg in agricultural engineering 1949, Purdue University. Machinist apprentice 2 yr. Plant breeder's assistant one year. Assistant agricultural engineer, design, one year. Experimental engineer, 4 mo. Engineer for pineapple plantation and cannery 4 yr, supervising all engineering design, construction and maintenance. War commissioned service (pilot) in Naval Air Arm, 3 yr. Available Oct. 1. Salary open. W-124-125

AGRICULTURAL ENGINEER for position in public relations, management, consulting, sales engineering, or education field. BS deg, some graduate work and 15 yr experience in writing, speaking and meeting public. Thorough knowledge of agriculture and electric power including water systems, irrigation, lighting and all types electric farm and home equipment. Also experience in soil conservation. Served as consultant on rural electrification and other

(Continued on page 280)

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Agricultural Engineers Yearbook

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Agricultural Engineers Handbook, to be published annually by the American Society of Agricultural Engineers, will include these main features:

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- ASAE Constitution, By-Laws and Rules
- ASAE Membership Directory (both alphabetical and geographical)
- ASAE-Approved Standards, Recommendations, Data, and Codes
- Directory of Suppliers to Agricultural Engineers (both an alphabetical list of leading manufacturers together with a listing of the principal products of each and an alphabetically arranged list of products and the names and addresses of the principal suppliers of each)

On publication each ASAE member will receive one copy of Agricultural Engineers Yearbook *without charge.* (The price is included in the annual membership dues.) Members of the Society are privileged to purchase additional copies—for personal or business use—at $2.00 per copy postpaid. The regular purchase price of the Yearbook to non-members of ASAE is $5.00 per copy. Address

American Society of Agricultural Engineers

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Personnel Service Bulletin

(Continued from page 278)

agriculture problems. Know how of technical research organization and conduct of field surveys and analyses. Worked with dealers, distributors, manufacturers, colleges, electric power suppliers, and farm groups. Organized and conducted training schools. Familiar with organization and function of federal government as related to agriculture. Minimum salary $5400 per year. Foreign employment: $7200. W-125-126

AGRICULTURAL ENGINEER for development, research, sales, service, or writing, in power and machinery field (writing in any branch of agricultural engineering) with industry or public service, anywhere in U.S.A., or Latin America, Australia, or Europe. Married. Age 39. No disability. BS deg in agricultural engineering 1940, University of Missouri. Farm background. Trainee in farm machinery and small machined parts plants 21 mo. Manual and technical report writing and review, 8 yr. Currently in civil engineering, determining hydraulic characteristics of streams with open channel flow. War enlisted service in Ordnance. Available on 30 days notice. Salary open. W-107-127

Professional Directory

RATES: 80 cents per line per issue; 40 cents per line to ASAE members. Minimum charge, five-line basis. Uniform style setup. Copy must be received by first of month of publication.

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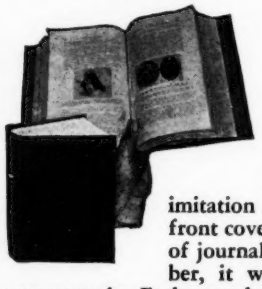

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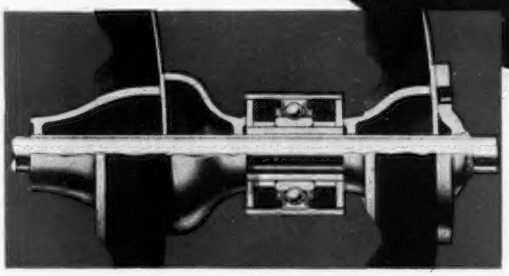
City.....State.....

NEW DISC HARROW SPECIFIES NEW DEPARTURES



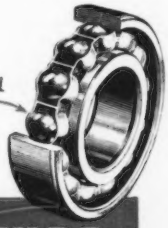
Sealed-for-Life **ball** bearings, pioneered by New Departure, are used in Allis-Chalmers' new grease-packed bearing assembly as standard equipment in their No. 30 disc harrow.

Built for heavy-duty farming! That's Allis-Chalmers' No. 30 disc harrow. And you'll find New Departure Sealed-for-Life bearings supporting the disc-gangs!

These outstanding **ball** bearings have been proved throughout the farm field. They seal lubricant in—dirt out. They carry all loads—radial, thrust or combination. And these New Departure Sealed-for-Life bearings are virtually maintenance-free!

When you design for the farm, talk with New Departure engineers. Their experience is always at your service.

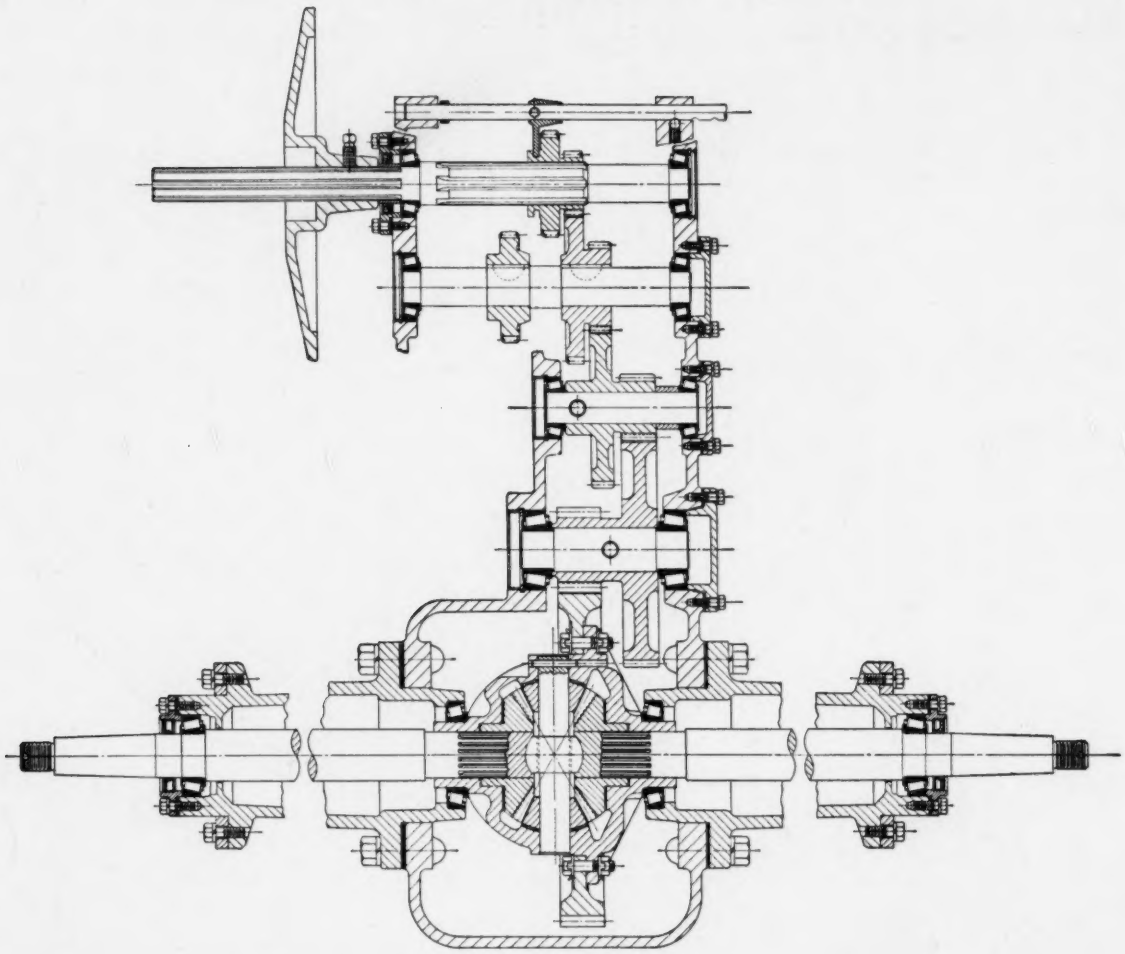
NOTHING ROLLS LIKE A BALL



NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

How Massey-Harris Keeps a Combine's Gear Train in Accurate Alignment



HERE'S an interesting problem in gear mounting—the transmission and differential of a Massey-Harris combine. In this train, the loads are usually quite heavy.

Massey-Harris engineers solved the problem by mounting the shafts on Timken® tapered roller bearings. The gears are held in accurate alignment because Timken bearings carry the load in a *full line contact* between races and rollers.

In field operation, these gears exert both radial and thrust loads. Timken bearings eliminated the need for extra thrust devices because their tapered design enables them to take both radial and thrust loads in any combination.

Timken bearings help solve three big problems in farm equipment—combination loads, dirt, ease of operation. By holding shafts concentric with housings, Timken bearings make closures more effective, help keep dirt out of the bearings, lubricant in. They drastically reduce friction in moving parts because they have *incredibly* smooth surface finishes and true rolling motion. They make equipment operate more easily and last longer. To get the best steel for Timken bearings, we make our own—the only bearing company that does.

Write now for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↓ AND THRUST →○← LOADS OR ANY COMBINATION